S. Hrg. 101-517

METHANOL AS A POTENTIAL ALTERNATIVE FUEL IN OUR FUTURE ENERGY POLICY

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

METHANOL AS A POTENTIAL ALTERNATIVE FUEL IN OUR FUTURE ENERGY POLICY

OCTOBER 17, 1989

Printed for the use of the
Committee on Energy and Natural Resources

U.S. GOVERNMENT PRINTING OFFICE
26-725
WASHINGTON : 1990

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S311-17

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METHANOL AS A POTENTIAL ALTERNATIVE FUEL IN OUR FUTURE ENERGY POLICY

TUESDAY, OCTOBER 17, 1989

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:30 a.m. in room SD-366, Dirksen Senate Office Building, Hon. J. Bennett Johnston, Chairman, presiding.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, U.S. SENATOR FROM LOUISIANA

The CHAIRMAN. The committee will come to order.

The committee has convened today to hear testimony on the role of methanol as a potential alternative fuel in our future energy policy.

The focus of this hearing is the President's clean alternative fuels program, which is contained in his proposed Clean Air Act Amendments of 1989.

To begin with, let me compliment the President for taking the initiative with his legislative proposal. Clean air is something we all want and something we all deserve, and I might say, something that too often we do not have. To the extent there is disagreement, it is only with regard to the chosen path.

The President's proposed legislation, S. 1490, was introduced by Senator Chafee on August 3, and referred to the Committee on Environment and Public Works. We understand that mark-up may begin this week.

So why is our committee holding this hearing?

First, this clean alternative fuels program is a federal fuels policy. And fuels policy is energy policy, and energy policy is this committee's business. We do not have a well defined energy policy in this country. The Department of Energy is holding town meetings across the nation as part of an effort to create a national energy policy, but for now it does not exist, unless it can be summarized in one word, "import. '

If we are going to back ourselves into an energy policy through environmental legislation, then we need to examine the President's alternative fuels proposal in terms of energy security, reliability of supply, and cost. The relationship of alternative fuels and global climate change is also a fuels policy question that should be addressed here.

I expect that our committee will hold additional hearings on other candidate clean fuels. This first hearing centers on methanol, because that seems for now to be ahead of the pack in the administration's bill.

Second, we are holding this hearing because it is a subject that justifies substantial scrutiny by more than just one committee. The House has conducted major surgery on this proposal, and there is some suggestion that it is an unwanted child. But whatever happens to this proposal, the subject will be with us for a long time to come.

The debate on alternative fuels will be occasionally contentious and perhaps ill-tempered, because there is much at stake in changing the status quo.

But before we force methanol or any other fuel on the driving public, it is our duty to ask a lot of questions. Those who offer the legislative proposal must bear a heavy burden of proof. What we do not need is a half baked alternative fuels program that flops. Public backlashes are not going to help the cause of clean air.

I come to this hearing with an open mind. It may be that clean air demands a switch to alternative transportation fuel. It may be that methanol proponents are right on the merits of their case. First, we must be convinced.

Before we hear from our first witness, Senator Burns, did you have some comments?

STATEMENT OF HON. CONRAD BURNS, U.S. SENATOR FROM MONTANA

Senator Burns. Thank you, Mr. Chairman, I just have a few.

First of all, I want to congratulate you and thank you for holding these hearings. The nation, everywhere that I have been in the last six months, is crying for two things. They are crying for a national energy policy that includes the mix of all the energies that we have technology to use.

And number two, they are crying for clean air, and especially in those areas like Los Angeles and those heavily-populated areas where we have got to do something about cleaning it up.

So I believe it is critical on the President's Clean Air Bill, that we fully discuss the implications of the proposed overall energy mix before we move to final judgment. We must all fully understand the overall energy implications of what we are proposing.

It was for that reason that I was a co-sponsor of a one-day seminar on the alterative fuels in Bozeman at Montana State University last week. We had good participation there, and we held that under my sponsorship in conjunction with the School of Business at Montana State.

I was pleased that the representatives of more than 30 national organizations participated in that meeting. And I wanted the opportunity to discuss the potential impact of alternative fuel development on the western United States and to explore the policy and technology issues that need resolution before alternative fuels can contribute significantly to our cleaning up the environment.

Mr. Chairman, we in the West are energy rich. We have ample supplies of traditional energy sources, oil, gas and coal. We are also rich in resources of energy for alternative fuel, such as ethanol, methanol, MTBE and ETBE, neat fuels, reformulated gasoline, and other alternative fuels.

We in Montana and other western states stand poised to be a part of the clean air solution and not a part of the problem. But I believe that some will testify that much of the methanol that will be produced to meet the President's clean air goals will be produced in foreign countries. And this sort of concerns me a little bit.

Mr. Chairman, we must think of our energy and clean air policies through and through. For that reason I applaud your initiative in holding this hearing and hearings to come, because as I travel the country, and I stated before, that we are going to need a mix, and there are two crying needs in this nation, a national energy policy and clean air. And both can be addressed through his vehicle.

Thank you very much. And I am looking forward to hearing from the witnesses.

The CHAIRMAN. Thank you, Senator Burns.

Senator FORD.

STATEMENT OF HON. WENDELL H. FORD, U.S. SENATOR FROM KENTUCKY

Senator FORD. I thank you, Mr. Chairman.

I am going to agree with my friend from Montana. But if we are energy rich, we need a policy or a program. Because now we receive over 50 percent of our oil from imports and we continue to allow ourselves to become energy deficient, in my opinion.

I also find that we are trying to clean up before we have a policy. We are beginning to make all these decisions before we have a program in place that we say is for this country, and ultimately, we could do a lot of cleaning up and it would cost the consumers and our taxpayers tremendous amounts of money.

And if I may say so, Mr. Chairman, I find no agreement among the energy industry itself to want to get together. And it seems to me that oil is for oil, and gas is for gas, and coal is for coal, and nuclear is for nuclear, and electric is for electric. They are all just wanting their piece and that is it, and they are not considering the country as a whole, and therefore, it leads me to believe that we may be getting the cart before the horse, because we are doing all this clean up and we do not know exactly what is going to follow.

So I look forward to the hearings this morning. And as you say, first we must be convinced. And when we are convinced, I think we ought to go. And I am very pleased that you are holding the hearing, even though the legislation was assigned to another committee.

[Senator Ford submitted the following:]

For Release 10 a.m.
October 17, 1989

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General Motors Corporation

AUTO/OIL AIR QUALITY IMPROVEMENT RESEARCH PROGRAM

WASHINGTON, D.C., October 17, 1989 -- The three U.S. domestic auto companies and 14 petroleum companies announced today a comprehensive joint research and testing program in which a wide range of fuels would be evaluated for use in both current and future cars and trucks.

At a technical briefing here, auto company representative Joseph Colucci, head of fuels and lubricants at the General Motors Research Laboratories, said, "This program is in support of the President's Clean Air Act proposal, which, for the first time, considers cars and trucks and the fuels they use as a total system.

"The first phase, which we hope to complete by mid-1990, is targeted at the fact-finding proceedings called for in the President's proposal. A second phase will investigate more advanced vehicles and fuels, and provide additional data for those proceedings," Mr. Colucci said. "We have designed the program to produce the best possible data with respect to representative alternative fuels such as reformulated gasoline and methanol."

Petroleum company representative Keith McHenry, senior vice president of technology at Amoco, explained, "The program's results will permit objective assessment of relative reductions in vehicle emissions and improvements in urban air quality, especially ozone, achievable with reformulated gasolines and with methanol fuels. The program will also evaluate ethanol as an additive to reformulated gasoline. The program has no bias as to which fuels are best for air quality."

-more-

2. Research

Participating auto manufacturers are Chrysler Corporation, Ford Motor Company and General Motors Corporation. Participants from the petroleum industry are Amoco Corporation, ARCO; Ashland Oil, Inc.; BP America Inc.; Chevron Corporation; Conoco Inc.; Exxon; Marathon Oil Co.; Mobil Corporation; Phillips Petroleum Co.; Shell Oil Co.; Sun Company, Inc.; Texaco Inc.; and Unocal Corporation.

"The joint research and testing was prompted by a common recognition by the domestic auto companies and members of the petroleum industry that we could enhance the quality of research by working together -- in addition to the research we are doing individually," Mr. McHenry continued.

"By working together on this specific program, as well as continuing to work separately, we believe we can more efficiently and effectively harness ideas from our scientists and engineers," said Mr. McHenry.

To that end, the companies are seeking the involvement of prominent researchers in the university community and from government agencies charged with environmental research. Those who will serve on the program's advisory panel are Professors John Heywood of the Massachusetts Institute of Technology, John Seinfeld of the California Institute of Technology, Robert Sawyer of the University of California at Berkeley, Professor Emeritus J. Stuart Hunter of Princeton University, and Dr. Jack Calvert of the National Center for Atmospheric Research.

Appropriate government agencies, such as the Environmental Protection Agency, the California Air Resources Board and the Northeast States for Coordinated Air Use Management, also are being asked to advise on the program.

The research program has two phases. The initial phase, to start immediately, will seek to determine the emissions, air quality effects and cost/benefit relationships of various methanol fuels used in prototype vehicles, and of reformulated gasolines used in 1989 as well as in 1983-85 vehicles.

-more-

3. Research

The methanol fuel vehicles will be prototype flexible fuel, variable fuel and gasoline-tolerant methanol vehicles being developed by the auto manufacturers. The current model vehicles will contain the newest technology emission control systems. Also in the test fleet are older high volume vehicles which will remain in use during the 1990s. The various types of reformulated gasoline will be created by varying aromatics, olefins, and oxygenate levels and the amount of components with higher boiling points. Additionally, ethanol (as an alternative to Methyl Tertiary Butyl Ether) and sulfur levels will also be examined.

During this phase of the program, all types of vehicles emissions -- exhaust, evaporative and running losses -- will be measured. These emissions will be characterized to determine specific chemical constituents by using sophisticated gas chromatographic techniques. The data from all of these analyses will then be used in atmospheric chemistry and air quality models to determine the potential reductions in urban ozone from use of any of the tested fuels.

A second phase of the research program is now under development with a projected start early next year. This program will use information from the initial phase to conduct research on advanced technology alternative fuel and gasoline-powered vehicles (future production vehicles). Other alternative fuels, such as Compressed Natural Gas, will be considered for inclusion in this phase of the program.

Part of this effort will explore the impacts on emissions and air quality by systems optimization involving current and reformulated gasolines and various vehicle emission control parameters. The relative cost effectiveness of the alternatives will also be determined.

"We hope the results of our joint research will produce sufficient scientific data to enable government and the public to make the best possible decisions on the fuels and technologies needed to make further progress in improving air quality," Mr. Colucci said.

#

The CHAIRMAN. Thank you, Senator Ford. And to respond to your statement about different forms of energy being in competition with one another. I am pleased to say that I think I have detected some cooperation among various energy forms in recent years; it is better than it used to be when one form really used to criticize the other. We have not gotten to a real cooperation yet, perhaps, and perhaps in a competitive market that is expectable, but at least we do not have the real fierce criticism we used to have.

Senator FORD. Well, Mr. Chairman, I say it may not be fierce criticism, but you do not see the lion and the lamb laying down together.

The CHAIRMAN. That is true.

Senator BURNS. Yet.

The CHAIRMAN. Senator Rockefeller.

STATEMENT OF HON. JOHN D. ROCKEFELLER IV, U.S. SENATOR FROM WEST VIRGINIA

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Obviously, I am very glad that you are having this hearing. And I am also pleased that there seems to be a consensus that at least some new fuels are necessary.

The great attention being given to reformulated gasoline shows that many in the oil industry agree that the status quo will not do. And for that I applaud them.

I do hope, however, that today's hearing will improve the character of the debate on alternative fuels. For example, I see a lot of stories in the media discussing problems with alternative fuels that do not discuss the problems with gasoline. I often read about the obstacles to moving to new fuels, but not about the many options available to overcome those obstacles.

We need to have, in my judgment, a much more can-do attitude, we need more cooperation, we need less bickering among competing fuels, we have a lot of it. We should not arbitrarily favor one or another fuel, but we should not freeze the status quo either.

We do need to move this country to new fuels, and the government is going to play a role.

As on many other items on the public agenda, the time for drift is over. We are very good at drift, but now we have to be good at some action. And for that reason I am glad to see that the administration is here. In our hearing on alternative fuels last June, the administration witness was decidedly lukewarm.

As you know from the recent defeat in the House Commerce Committee, the administration's alternative fuels initiative is in lots of trouble. I hope we will learn today about the administration's plan to get back in the ball game, if not with the original Bush proposal, then with a strong program to promote alternative fuels.

In the council of decision-making in Washington, the future speaks with a very weak voice. If we do not hear that voice soon, there will be a steep price to pay. Clean air is at a premium, domestic oil is running out, time is running out; I look forward to hearing the witnesses.

The **CHAIRMAN**. Thank you very much, Senator Rockefeller.

[Prepared statements of Senators McClure and Nickles follow:]

OPENING STATEMENT
SENATOR JAMES A. McCLURE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
TUESDAY, OCTOBER 17, 1989

METHANOL AS AN ALTERNATIVE FUEL

American consumers continue to rely on the automobile as their principal source of transportation. But when we look to our energy strategy for the 1990's and the 21st century, our continued reliance on gasoline to power these vehicles has significant energy and environmental implications for all Americans.

Recently, the Bush Administration proposed an ambitious program to create a market for alternative-fuel vehicles. This program is prompted by the failure of about 100 areas in our country to meet the ozone ambient air quality standard mandated by the Clean Air Act. Spurred on by concern to find a much needed solution to this critical problem, the Federally mandated program envisions the production of 9,250,000 alternative-fuel cars over the 10-year period from 1995 through 2004, or 500,000 of these cars in use by 1995, another 750,000 in 1996, and one million cars per year from 1997 through 2004.

While the program is supposed to be fuel neutral, both the Environmental Protection Agency and the State of California have constructed strong environmental arguments in support of methanol as the alternative fuel. Yet a number of studies indicate that methanol is and will continue to be considerably more expensive than gasoline. Moreover, the potential suppliers of methanol are primarily foreign: Trinidad, Saudi Arabia, Australia, and perhaps Alaska. Therefore it is important that these hearings examine the full implications of such an endorsement of methanol for our national energy strategy.

Several members of this committee wrote Chairman Johnston on June 13th requesting hearings on the energy policy implications of the acid rain, alternative fuels, and clean coal provisions of the President's proposed Clean Air Act Amendments. I have been assured that this hearing is not intended to satisfy that earlier, broader request.

Since the gasoline lines of the 1970's, the Department of Energy has examined several alternatives which would extend or replace gasoline supplies. Among these, alcohol fuels have received the most attention as either a "neat" fuel or in low concentration blends with gasoline.

Over the years this Senator has consistently supported Federal tax incentives for alcohol fuels. During the last Congress I also supported enactment of the Alternative Fuels Act of 1988 which authorizes a modest Federal program to foster markets for alternative fuels. But this is not all we can do.

Recent efforts by the California Energy Commission indicate that several of these alternative transportation fuels offer potential environmental benefits compared to gasoline; in particular, reduced effects on global climate change. Other alternatives have included reformulated gasoline, ethanol, diesel, compressed natural gas (CNG), propane and butane (LPG), electricity and hydrogen. However, each of these alternative fuels has its own unique health and safety concerns.

Some of these alternatives have achieved consumer acceptance. For example, since Federal economic incentives were provided in 1978 for the production and sale of ethanol, sales have continually climbed. In 1988, eight percent of all gasoline sold in the United States was a 10 percent gasohol blend. About 320 million bushels of corn were consumed annually to make this ethanol. This is not only good for our national energy security and environmental quality, but it is also good for our nation's farmers.

Besides gasohol, there is LPG (or propane and butane), which is the most widely used alternative motor vehicle fuel in the country and the world. Over 330,000 motor vehicles in the United States and 2.5 million in the world rely on LPG.

Several other alternatives offer immediate potential environmental benefits. Among these are compressed natural gas (CNG), methanol from natural gas, and petroleum-based reformulated gasolines. Other options include certain fuel additives, in particular oxygen enhancers such as methyl tertiary butyl ether (MTBE) from methanol, and a new product made from ethanol -- ethyl tertiary butyl ether (ETBE). Such oxygenated additives not only reduce emissions of carbon monoxide, ozone and air toxins but improve automobile fuel economy as well.

The importance of alternative fuels in meeting our country's energy and environmental challenges is generally recognized by our domestic automobile and oil industries. I am informed that this morning it is being announced that Ford, GM and Chrysler are joining with 14 oil companies in a comprehensive research and testing program to evaluate a variety of alternative fuels to determine the emissions, air quality effects and relative cost effectiveness of using such fuels as ethanol, methanol, natural gas and petroleum-based reformulated gasoline.

Methanol, which is being discussed here today, is one of those alternatives, but it is accompanied by its own energy, economic and environmental problems. The Congressional Research Service has concluded that "the long-term (say 20 years) economics will probably not be favorable unless a significant set of independent nongovernment decisions turn out favorably for methanol costs."

All alternative fuels are an important energy supply option which must receive particular emphasis in any energy strategy for the reduction of oil imports. Because of this reality, I am looking forward to today's testimony.

STATEMENT OF SENATOR DON NICKLES
HEARING ON THE ROLE OF METHANOL AS A POTENTIAL ALTERNATIVE FUEL IN OUR FUTURE ENERGY POLICY

OCTOBER 17, 1989

Mr. Chairman, I thank you for holding this hearing today to discuss the potential of methanol as a motor fuel supplement to gasoline and diesel. It is appropriate that the Energy and Natural Resources Committee participate actively in this debate, which recently has been, I believe, too narrowly focused on methanol's potential contribution to ozone reduction.

In considering federal policies that will encourage shifting away from our reliance on gasoline and diesel fuel as our virtually exclusive transportation fuels, the Congress must adequately consider and balance all related national priorities. I am very concerned about the national energy security implications of our dependency on imported motor fuels. It would be grossly unwise, in my view, for the Congress to pass legislation that would have the effect of mandating the use of large volumes of imported fuels. For example, I do not favor ethanol tax credits to support imports of ethanol.

Competitively priced methanol is not and will not be manufactured in the United States for the forseeable future. This Nation's natural gas is simply too valuable to be turned into methanol. Rather, methanol will be made by countries with no other market for their gas, such as Saudi Arabia and Trinidad. We are currently spending about $40 billion a year on oil imports. The best way to stop this financial hemorrhaging is to replace imported oil with domestic fuels. We should be opening ANWR for environmentally sound oil development, and proceed with prudent development of our oil and gas resources on the Outer Continental Shelf. We should increase tax incentives for domestic exploration and production from our domestic oil and gas resource base. We should encourage the "reformulation" of gasoline to meet near-term clean air goals and, for the longer term, encourage increased use of domestically produced alternative motor fuels, such as compressed natural gas and liquid petroleum gases. At a minimum, we must give proper weight to energy security and our balance of payments while we are considering the best way to address urban ozone.

I am particularly interested in the testimony today on the cost of increasing the use of the various alternative fuels. Up to now, the cost to the motorist and the taxpayer have not, in my view, been adequately considered. Enacting policies that essentially require the use of methanol would require the building of entirely new distribution and retail systems and require consumers to purchase "dedicated" methanol cars, which could not be fueled by gasoline. More consideration must be given to alternatives that can achieve substantial reductions in tailpipe emissions which are not prohibitively expensive. Clearly, a less costly approach would be to reformulate gasoline or encourage gasoline/methanol mixtures that can be used in "flexible fuel" vehicles. I am interested to learn from today's witnesses what measures can be taken to minimize the infrastructure overhaul needed to meet reasonable clean air objectives.

Finally, I have serious concerns that the Administration's Clean Air Act Proposal would have the effect of mandating the purchase of one million alternative fuel vehicles per year by the year 2000. This provision raises real cost and equity considerations, that would especially be problematic if the clean air legislation or regulations would set tailpipe emission standards that could only be met by neat methanol.

Thank you, Mr. Chairman. I look forward to the testimony.

The **Chairman**. Before we hear from our first witness, I might mention that I am a member of the HUD and Independent Agencies Appropriations Conference and have got to go over and handle an amendment, which will take about 30 minutes, somewhere around 10:00, whenever I receive word, so if I go out, it will not be because I am protesting what the witness has to say or lack interest, but because I have got to go handle that amendment.

Our first witness will be someone well known and respected by this committee, Bill Rosenberg, whom we confirmed as part of FEA back in the good old days of energy. He is now Assistant Administrator for Air and Radiation of the United States Environmental Protection Agency.

He is accompanied by Richard D. Wilson, Director for the Office of Mobile Sources; and by Charles L. Gray, Jr., Director of Emission Control Technology Division at Ann Arbor, Michigan.

Bill, we are glad to have you, and please proceed.

STATEMENT OF WILLIAM G. ROSENBERG, ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION, ENVIRONMENTAL PROTECTION AGENCY, ACCOMPANIED BY RICHARD D. WILSON, DIRECTOR OF MOBILE SOURCES; AND CHARLES L. GRAY, JR., EMISSION CONTROL TECHNOLOGY DIVISION

Mr. **Rosenberg**. Thank you, Senator, members of the committee. Mr. Wilson is on my right and Mr. Gray is on my left.

I would like to present testimony essentially in three parts, using charts to explain our position.

The first part will deal with the environmental implications of the bill and why the EPA believes clean fuels are absolutely essential to meet the health and welfare goals under the Clean Air Act; the second part will be a description of the President's clean fuels program and how it works; and in the third part I will attempt to address some of the more commonly asked questions about the program; and then of course we will be available for the committee for additional questions.

One thing that we can start with is that the auto industry, pursuant to action by the Congress since 1970, has been fabulously successful in cleaning up emissions from automobiles. On a per-car basis, today's cars produce 80 percent less hydrocarbons, 80 percent less carbon monoxide, and 60 percent less NO_x.

So, since controls went on in 1970, after the 1970 Clean Air Act, the auto industry has been very successful in achieving technology improvements. This is what we are up against, though, the growth in the use of the vehicles. The growth in the miles travelled have almost offset the technological advantages achieved in the auto industry.

Since 1970, the amount of miles driven has gone up 60 percent, and we project at EPA, and this is confirmed by DOT and others, that at 2 or 3 percent annual growth for the next 15 years, we are looking at another 60 percent increase.

So with that type of growth in the use of the vehicles, a 60 or 80 percent improvement in technology does not solve the environmental problem.

I would like to talk today about essentially two environmental questions that the Clean Air Act principally addresses. The first is urban ozone smog and the contribution of motor vehicles and other sources, which we call them at EPA, to urban smog.

Essentially, urban smog comes from hydrocarbons emitted into the air, reacting in the presence of sunlight and heat to form ozone. And ozone is what causes the health problems. And it is the level of ozone in the atmosphere that is the measurement of the EPA health standard that is significant.

I must say that our 1988 measurements show that 101 cities in the United States did not meet the health standard at various times of the year, affecting over 100 million people. So the ozone problem is our most serious environmental problem and it comes, essentially, from three major sources.

Motor vehicles, you will see, account for 45 percent of the hydrocarbons that are the major precursors to smog; small area sources, everything ranging from paint that evaporates when you paint your house, to bakers or dry cleaners, account for 40 percent; and large factories only account for 15 percent.

And what this points to is that if you are going to achieve significant reductions, and we do need significant reductions to meet the health standards, you need to get it from everybody. If you were just to rely on the factories, that would be only 15 percent of the total cause.

The CHAIRMAN. Let me interrupt you, and I do not want to start the questioning at this point, but just to be clear on ozone. Ozone is not like CO_2 that travels around the world, it is an urban thing that drops out in close proximity to the urban area, is that right?

Mr. ROSENBERG. There is good ozone and bad ozone. The good ozone is way up in the stratosphere and that is what we are worried about with the CFC problem. And that is what shields the Earth from ultraviolet rays. That is the good ozone we are trying to protect.

The bad ozone is what is formed through the reaction of sunlight and the hydrocarbons on the ground, that people breath.

The CHAIRMAN. But it does not travel from the west coast or the east coast or from here to the mountains in Hawaii, like CO_2?

Mr. ROSENBERG. Well, it does travel some, sir. You will see that Hartford is one of the dirtiest cities in America and it is one of the programs under the President's bill. It gets its ozone very much from Baltimore, Philadelphia and New York as it moves up the coast.

And we have seen, for example, in the Grand Canyon, some of the ozone problems there come from the west coast. It does not go absolutely across the country, but there is a transport problem, and one of the issues technically raised in the bill is to set up a commission in the northeast, for example, to study that transport problem in the northeast.

In Kennebunkport, a well-known place that the President goes to in the summer, it quite often has an ozone problem and there is no industry. It is all moving up from Boston and from New York.

The CHAIRMAN. It is that speedboat. [Laughter.]

Mr. ROSENBERG. The second principal air pollution problem we are concerned about as it relates to this bill is what is known as air toxics, and of course those are toxic chemicals that cause cancer and there are about 3,000 cancer deaths a year associated with air toxics.

About half of them 56 percent—emanate from motor vehicle emissions, and so one of the goals in our program is to reduce the amount of air toxics. Only 20 percent come from large point sources, large factories, and yet that is the portion of the bill—you have probably heard that there are three parts of the bill, one is air toxics. That only addresses the 20 percent of the bill. The alternative fuel program and our motor vehicle program generally address the 56 related to motor vehicles.

So the President's program, as it relates to mobile sources, and I will not go into all this detail, is quite elaborate. Leaving out the clean fuels at the bottom of the second column and the third, all the other provisions really relate to cleaning up essentially the current car, gasoline-driven car, improving the quality of the fuel, reducing its volatility, adding oxygenated fuels to it, and then doing things like reducing the emissions from refueling—as you see here, you have those vacuum systems at the pump—and we have divided that into three areas, certain things that we can do that will affect near-term activities like the fuel improvements, better inspection and maintenance and clean fuel buses.

In the mid-1990s we are focusing on changes in the car technology, the tailpipe standards, better diagnostics, vehicle evaporative control and diesel fuel controls, and then in the mid-1990s we move into the area of setting up a clean fuels program, trying to solve the chicken and egg problem.

Can you have the cars without the fuels? Can you have the fuels without the cars? Dealing with that, and then going into the post-2000 and advanced clean fuel program.

The CHAIRMAN. Why do you not stay on this one. The gasoline companies argue that much of your pollution from ozone comes from the old automobiles. Could you tell us what percent of automobiles are old, while you are there, and what percent of the problem of ozone is caused by old automobiles?

Mr. ROSENBERG. Well, we sell about 16 million cars and trucks a year. That is a little bit under 10 percent, so each year the cars get better and as we phase out the old cars we are phasing in new cars, but our sense is—I will show you the next chart—that even the cleaner cars need a substantial amount of improvement.

So that—in fact the next chart kind of demonstrates that issue, that the current gasoline car, for example, is represented by the first column and that is the amount of pollution—that is on a reactivity-adjusted, in-use calculation—of the current gasoline car, even the new cars.

The President's proposals would require cars to be designed in accordance with the second column. The third column represents the cars, if the Senate's—the Senate Environmental Committee has come out with a proposed bill and in a two-phased program so that in the year 2000 the car designed under those restrictions would have that level of pollution and the clean fuel car that the President has proposed would operate with that amount of pollution control on the right.

I might point out here something very interesting, which is 70 percent of the current gasoline car emission problem comes from the evaporation of the fuel, either evaporation of the fuel at the pump when you fill up the car, evaporation when you are driving the car, or evaporation when the car cools down.

The **Chairman**. How does that happen? How does it evaporate when it is in the tank?

Mr. **Wilson**. What happens is, there is a canister in the car that collects those vapors. We found that the fuel is higher volatility so more vapors are generated than the canister can hold, and the system works that it releases the vapors into the atmosphere when that happens, so that is one of the reasons for——

The **Chairman**. What canister are you talking about?

Mr. **Wilson**. It is a charcoal canister on the car to collect these evaporative emissions.

The **Chairman**. I just want to know the simple question of, how does gasoline in a tank evaporate?

Mr. **Wilson**. Well, vapor is created over the liquid level in a tank and as the tank, for example, heats up and cools off over night, as it heats up it generates more vapors. The vapor pressure then goes into this canister that is there to collect the vapors and if it is not sized properly they will escape into the atmosphere.

The **Chairman**. Well, I still do not understand, but go ahead.

Senator **McClure**. Could I ask one question at that point? How much of the increased volatility is because of the high end aromatics that are used to obtain higher octane ratings?

Mr. **Wilson**. For the most part the higher volatility is caused by butane being added to the gasoline which has only a quite small octane benefit for the fuel, so it is not so much the aromatics for octane as it is butane that has been added.

Senator **McClure**. Well, it is a fact, is it not, that since lead was removed from gasoline high end aromatics have been substituted?

Mr. **Wilson**. That is true.

Senator **McClure**. Are high end aromatics more volatile by definition?

Mr. **Gray**. Not necessarily. The aromatics are fairly heavy hydrocarbons and are not as volatile, do not have as much tendency to evaporate as the gasoline constituents like the butanes and pentanes, or other lighter hydrocarbons, so when you do a speciation analysis to determine what the composition of these evaporative emissions are, you find predominantly these very light hydrocarbons. You find a small percent of aromatics, but the large majority are the smaller hydrocarbons like butanes.

Mr. **Rosenberg**. One of the things that the President's bill attempts to do is reduce this evaporative problem, and so you can see that in the second chart——

The **Chairman**. Well, let me ask again, how does gasoline in a tank evaporate? It is a simple question.

Senator **Burns**. How does it escape?

Mr. **Gray**. First of all, as Mr. Rosenberg mentioned, there are several modes in which it will be generated. The most typical is when the fuel in the tank heats up once the car starts.

A typical vehicle on a typical urban drive, the fuel tank's temperature will rise about 20 degrees from ambient temperature, and in fact on a hot summer day when you have an ozone problem, your gasoline in your tank today will probably literally be boiling and that is how it generates vapors.

So all of those hydrocarbon vapors have to go somewhere or the tank would have a pressure release valve to relieve that high pressure, and so they are routed to this carbon canister—it looks like a coffee can on some vehicles full of activated carbon, and the carbon absorbs these hydrocarbon emissions and then the engine pulls air to the canister and pulls off the hydrocarbon vapors and tries to burn the vapors in the engine.

If the canister receives too much vapor from the tank it will be saturated. It cannot hold any more hydrocarbons, and there is a vent in the canister that then will vent those vapors to the atmosphere, and that is what is happening now. We are overloading the canister and the high volatile gas——

The **Chairman**. Then to the outside?

Mr. **Gray**. Then to the outside, through the canister. If the gas cap does not seal properly it does not even bother going through the canister, it goes straight into the air.

Mr. **Rosenberg**. Plus, when you refuel the car, when you open up the gas tank you release some of those hydrocarbons as well. So you have a refuelling problem and you have this operating problem, and so one of the things that—one of the important aspects of the President's proposal is you reduce that and thereby reduce the amount of the evaporative losses, which is one of the reasons why our second column is so much lower than the current car, to fix that technologically.

It is important, I think, to point out, the black part of that chart is the amount of emissions that come out of the exhaust pipe and the lighter part is the amount that comes out of the—that is evaporative losses and the reactivity of those emissions, so you can see that there is a tremendous amount of work that can be done on reducing evaporation at relatively low cost, which is one of the initiatives of the program, and the tailpipe restrictions only get some of the benefit, and that is not something that is well known.

There are less evaporative losses with clean fuels because clean fuels are less volatile—and clean fuels, and by that I mean CNG, ethanol, methanol, or a reformulated gas that has the same qualities as those fuels, would by definition be much lower in volatility and therefore would be less evaporative control.

The **Chairman**. Staff has just mentioned to me that one of the reasons that you get this hot tank with the boiling gasoline is because it is put next to the tailpipe and that—ext to the muffler, and if you would insulate that, that you would solve that problem and it would not be hotter than the ambient air. Is that right?

Mr. **Gray**. That is so—one of the sources of the fuel tank temperature rise, but it is a combination of several factors. New cars are almost all now fuel-injected. That recirculates hot gasoline back to the tank. That increases the temperature of the tank.

Today's cars are being designed more compact and so routing the exhaust pipe closer to the fuel tank becomes a problem and it occurs on many vehicles. But most of the heat to the tank does come from the hot engine heat.

Air has to flow through the engine to cool it, through the radiator, engine, and then it goes under the body of the car, and that hot air is the principal source of the heat that increases the temperature of the tank.

In fact, we are seeing—the temperature rise of fuel tanks seems to go up with newer cars, as they are becoming more streamlined and more compact in terms of the fitting of components under the car, so it is probably going to get worse instead of better, unless some additional costs are imposed on vehicle owners.

Mr. ROSENBERG. The second environmental issue was the question of air toxics and this chart is intended to represent the levels of air toxics. Essentially, the cancer incidences that come from the burning of the fuels. The chart on the left, the column on the left represents the 1995 gasoline car, the gasoline car that will be built with all of the improvements required under the President's bill.

I think it is important to note here that in all the different fuels, the black portion is the amount of formaldehyde and the cancer incidences caused by formaldehydes. In the gasoline car you will see there is a lower amount. There is some formaldehyde, but there is quite a number of toxic emissions from benzene, refueling vapors and butadiene and POM.

The second column represents M85 fuel, which, while it has more formaldehyde incidents per unit, would have an overall reduction in the amount of cancer incidences by about 40 percent because there is less benzene emitted from M85 and much less 1-3 butadiene and POM.

The third column represents E100 or M100, which would be essentially pure alcohol, either ethanol or methanol. It does not have anything but formaldehyde. It is slightly above the cars, but it has nothing else, and the one on the right which is compressed natural gas has the lowest incidence of air toxics, 95 percent reduction from the gasoline car.

The point of this is that when you look at the toxicity of exhausts from fuels, the point that you made, Senator Rockefeller, you have to compare it to something.

It is not compared to clean air or clean water, it is compared to gasoline, and our judgment is that even in a very well-controlled car, the alternative fuels that are being discussed, will all have a much lower incidence of cancer releases from air toxics than a well-controlled gasoline car.

Senator ROCKEFELLER. Mr. Chairman, not to interrupt, which I am, but that I think is a very significant chart because formaldehyde is constantly mentioned—constantly mentioned by those who attacked methanol.

Of course, they never mentioned benzene in gasoline, but they constantly mentioned formaldehyde, not even referring to a secondary reaction, and yet you still say on this chart very clearly that overall toxicity diminishes dramatically.

Mr. ROSENBERG. There is no question about it. Those are our risk analyses and really this is the hidden problem, in a sense, with all fuels, is the air toxicity question—air toxics. In fact, today EPA is announcing that it is going to undertake a major study of the toxicity of all motor fuels and upgrade our information, but this is pretty strong information based on our normal risk assessment procedures.

I would like to move quickly through the rest of it if I may. The President's program applies—the clean fuels activities—in nine of the dirtiest cities, and you can see that it is not just Los Angeles, it is San Diego, Houston, Milwaukee, Chicago, Baltimore, Philadelphia, New York and Hartford.

So in those nine cities, that is where the concentration which are cities that we do not believe will achieve the healthful levels without some major improvement of this type. This is where the program will initially start.

In describing the program, I think one of the basic misconceptions is that it is geared towards methanol. It is not. It is fuel and technology neutral, and the way in which the program works is that in these nine dirty cities, beginning in 1995, 30 percent of the new vehicles simply must be much cleaner than the other vehicles, and EPA will establish performance standards and we estimate that these are what those standards would be:

In 1995 there would be a 30 percent reduction of hydrocarbons compared with the gasoline cars that are being sold then, and a 40 percent reduction to the air toxics. In the year 2000, that would step up to an 80 percent reduction in hydrocarbons and a 90 percent reduction in toxics.

That is the EPA standard. It does not say methanol, it does not say ethanol, it does not say CNG. It just has a level of environmental performance. It is up to the industry, using its own market forces and its own ingenuity, to meet those standards in any combination of fuel or technology, and as long as the cars are certified to operate at these lower levels, then the cars would be acceptable whether they run on reformulated gasoline, or ethanol, or methanol, or CNG, or anything else that they can develop.

So it is a combination of engine and fuel technology that is fuel neutral to meet a standard that gets us a reduction from these 30 percent of the vehicles that is much greater than the reductions we get from standard gasolines.

Once the auto makers decide what combination of technology and fuel they can use to meet those standards, EPA will assure that that fuel is available at the pump by requiring the service stations and the fuel industry to make that available.

This is very similar in concept to the introduction of unleaded fuel in the 1970s, where the cars—the auto companies were obligated to put on catalytic converters—well, they were actually obligated to meet a certain standard and they chose to put on catalytic converters to meet that standard, which required the use of unleaded fuel and then EPA required that unleaded fuel be conveniently available.

So the regulatory program of introduction of catalytic converters and unleaded fuel in the 1970s would be similar to what we would propose in the 1990s for these cleaner fuels.

We were concerned about what impact this would have on the refineries in America, and I think it is important to note that in our opinion petroleum demand would continue to grow even in these nine cities, that they just would not grow quite as fast as they would if they did not have clean fuels.

The clean fuels program relates to about one-third of the growth estimated in the increased gasoline demand, so the petroleum markets would continue to grow and grow at a smaller rate.

I might point out that even though 1 million cars certainly sounds like a lot of cars, which it is, that represents only 7 percent of the market. What we are attempting to do here is have a program that impacts a small percentage of the market but concentrates that in the cities that need the help the greatest.

Two questions asked are will the consumers buy the vehicles and will they buy the fuel. That is obviously a key point because consumer acceptability is the bottom line. Nobody is requiring people to buy cars, and nobody is requiring people to buy the fuel. So we try to design the program to minimize consumer reluctance.

The initial vehicles, we are told by the auto industry, would be essentially no risk vehicles. They would be dual fuel vehicles that could run on gasoline or the alternative fuel, depending upon what the consumer wants. There would be very few changes in the vehicle itself.

I am told that only 30 of 5,000 parts would have to be modified to make these dual fuel vehicles, and because these fuels are very high octane they should perform very well.

For example, M85 is a 98 octane fuel, M100 is a 99 octane fuel, and CNG is 120 octane fuel.

Senator McClure. Now stop just a moment right there, because, you see, they are dual fuel automobiles but they are going to be high octane, and I assume the next stage is that they are going to be very efficient, therefore they have higher compression ratios.

If they have higher compression ratios, then they are going to operate on gasoline.

Mr. Rosenberg. No. In the first phase, we do not believe that the cars will be more than 5 percent more efficient because of that very point you made, Senator, which is that they have to operate on both gasoline and dual fuel.

Senator McClure. Then they will not be significantly more efficient.

Mr. Rosenberg. That is correct. In the first phase, we expect the efficiency to be in the 4 to 5 percent improvement; but in the second phase when they operate on dedicated vehicles, whether it is dedicated ethanol, methanol, CNG or reformulated gas that gets the same benefits, then we would expect to see 25 to 30 percent efficiency improvement.

The fuel will be conveniently available, and because the automakers have the obligation to sell the vehicles, we expect they will design, promote and price the vehicles to insure that they will be sold.

Nothing is more important, Senator, than the CAFE credit under your bill last year to provide the incentive for the auto industry to in fact market the fuel successfully. We estimate that the cost of adapting the fuel in a dual fuel capability is about $200 to $400 or maybe $300 on an average but that the CAFE credits might be worth $1,000.

So there is every incentive for the auto industry to price these in a competitive way.

The second point is why will consumers buy the fuels if they are available. Well, there is indeed considerable experience with clean fuels in the United States and around the world. In the U.S., many of the gas utility companies operate CNG vehicles, for example. We understand there are 30,000 CNG vehicles operating in the U.S. In Brazil, ethanol is a very major fuel. In Holland, LPG is an important fuel. So where there has been experience, consumers have enjoyed that.

The Federal requirement will ensure that the fuels are readily available in these cities. As I pointed out, clean fuels will be at a premium.

Very, very significant, of course, will be whether they are price competitive. We have a provision in the bill that requires the states to assure that the fuels are used. In that regard, if in fact the fuel is not price competitive, which in the next chart we will show you why we believe it will be, the states could require the sales requirements for the clean fuels as a way to meet their clean air responsibilities much the way the national law requires the auto companies to sell these cars as a way to achieve clean air. So under the clean air regulations we would expect that states could have the authority to do that.

Senator **McClure**. Could I ask one question at this point?

I understood you to say Brazil is methanol.

Mr. **Rosenberg**. Ethanol.

Senator **McClure**. I think you said methanol.

Mr. **Rosenberg**. Made from sugar cane. Of course, we make lots of ethanol in the U.S. from corn.

The next chart kind of gives you what Charles' group in Ann Arbor, which has been working on this subject for ten years—I might point out that there was an interesting confluence here on how we got to the President's program.

The President himself, you know, is an advocate of alternative fuels. When I came to the EPA in February with Bill Reilly, we found out that the EPA lab in Ann Arbor under Mr. Gray has been working on this subject for ten years, so we had lots of information, economic information, technical information and environmental information to bridge the gap between the political and the factual and the scientific data.

This was done about a month or so ago. At the time, gasoline was selling for between $1.08 and $1.23 a gallon. Today in California, M85 being used in a flexible fuel vehicle on a gasoline equivalent basis, taking into account the fact that alcohol requires more volume and has less energy per gallon, was selling when we did the study for between $1.15 and $1.23 today in California.

We estimate that in the future once the economies of scale can be realized by the production of large methanol plants or other alternative fuel plants, the price will come down in terms of current prices so that M85 in 1995 would be under $1.10 per gallon and M100 in the year 2000, taking into account the efficiencies that Senator McClure mentioned, would have a gasoline equivalent under 90 cents per gallon.

The **Chairman**. This is very heavily disputed, is it not?

Mr. **Rosenberg**. That is correct.

The **Chairman**. Why is it disputed?

Mr. **Rosenberg**. This is the heart of the discussion in some respects. I know why, and I think the division essentially is between EPA and the California Energy Commission and the air people, the government people on the one hand, and the oil industry on the other hand. They have different points of view.

I read over the weekend the new Congressional Research Service report. Our data and the California data is pretty comparable, and API's data and SRI, which presented data on behalf of the oil companies in California, is a much higher cost.

I think it is important for the committee to review the details. We certainly would work with staff to do that and have already presented our report to you.

The **Chairman**. Here is your chance to tell us why we ought to accept your data rather than the others. We are skeptics. We want to believe, but why should we accept your data?

Mr. **Gray**. Certainly there are a lot of components that go into a pump price. You have to go back and look at the cost of raw material, the capital cost of converting that raw material into, in this case, methanol, the operating cost for the plants, the profit for the investors in the plants, the transport of the fuel to the terminals, transport to the service stations, the mark-up at the service stations so that everyone can have at least the same profit they have in handling gasoline.

So the basic approach we use, if you look at it step by step, we feel is quite conservative. There are only two fundamental, complete engineering studies of fuel methanol. One was done by Bechtel in California under the direction of Chevron and six other oil companies, a very comprehensive engineering study. The other is one done by Chem Systems, another reputable engineering firm, done by the Department of Energy.

Both of those studies looked at conventional technology because methanol is already produced at the figure of 6 billion gallons per year, so there is no uncertainty about what it takes to make it. These processes were based upon conventional technology. They used natural gas prices based upon DOE's projections. They used profit for the investors of 10 percent return on investment after taxes, and that is better than the fuel industry achieves now. We use the same mark-up, because this program produces the same volume of sale of gasoline as unleaded regular in these cities as it is phased in. It is 30 percent of the sales in just the biggest stations. We amortized the equipment, applied that to the cost, provided a higher profit to the service station operator for handling that fuel, and ended up with these figures.

So we feel from an objective engineering perspective that each step of that analysis which is laid out in detail in our report—and we would welcome any specific difference to those assumptions, and we would be glad to address it because we think they are quite conservative.

The **Chairman**. You assume foreign made natural gas?

Mr. **Rosenberg**. Yes. We assume either remote natural gas either in foreign sources or in Western Canada or the North Slope of Alaska.

One of the real issues is the question of what will the feedstock, the natural gas feedstock, cost to convert this natural gas to methanol. Our sense here is that if you principally concentrate on remote gas that is now being vented or flared, there is twice the amount of gas being vented and flared in the world today than would be required to produce methanol under the President's program 100 percent.

In addition, there is a lot of gas that is coproduced with oil that is being reinjected. In the North Slope of Alaska, for instance, there is a tremendous amount of natural gas that is being produced with that oil that is being injected back into the ground.

It is technologically feasible in the North Slope to convert that gas to a liquid methanol and have it come down the pipeline. Right now that would be more expensive than getting it from abroad, but that is certainly not the technological issue.

So the real issue with respect to methanol is what will this wasted gas cost. Our sense is on a netback theory it will cost an amount that would not drive the price of methanol beyond its value at the pump as measured by gasoline. So the natural gas markets to which we would look, the remote markets where there is no other way to sell the gas, principally stuff which is being vented and flared right now but others that are being capped and not produced because there is no pipeline in these remote areas, would provide the hydrocarbons at a competitive price that would allow methanol to be priced competitive to gasoline at the pump.

Senator ROCKEFELLER. Mr. Chairman, could I just ask if there are any comparable cities as to what gasoline might cost?

Mr. GRAY. Certainly there are several projections. The difficulty with gasoline, as all of you well know, is that future prices are not engineering costs derived. They are projected because the price of gasoline is not associated with the same kind of economic factors that we have with something like methanol.

We can from an engineering perspective much more clearly define what the cost of methanol would be and then challenge anyone to say why it would be more unless they specify that the natural gas would cost more to the plant or someone would make more profit. It has to be one of those two factors before you will have a higher methanol price.

With the world's oil supply being now 80 percent controlled by OPEC nations, OPEC specifies future oil prices. DOE's projections are the ones that we use. Of course, they project much higher gasoline prices absent competition in the motor fuels sector. This will provide that competition and could very well suppress gasoline prices.

Senator ROCKEFELLER. It would be highly unlikely that there would be any scenario by which the cost of gasoline would show a decline in price that you indicate here.

Mr. GRAY. The break-even price for a flexible fueled vehicle would be oil at about $14 per barrel. The break-even price for a dedicated methanol vehicle would be less than $10 per barrel. So the oil exporting countries would have to drop the price of oil to that degree, which would of course be hundreds of billions of dollars savings per year for the U.S. if this program caused them to do that.

Senator MURKOWSKI. Mr. Chairman, if I may, Mr. Rosenberg, you indicated reference to North Slope gas in your comments, the

76 trillion cubic feet of gas that has been found as a consequence of searching for oil in the Prudhoe Bay area.

I am interested, since obviously the President is very committed to this methanol clean air, if EPA is considering the merits of doing an evaluation on the economics of bringing the gas liquids down in the existing pipeline since it is already there and whether or not that study would emphasize specifically the economics, the economic factor of bringing that gas down the pipeline.

Mr. **Rosenberg**. Our report did attempt to analyze that not from the point of view, Senator, of bringing the gas down as gas but from the point of view of converting the gas up in the North Slope to a liquid and then backshipping it down to the pipeline.

It is our understanding based on some tests done in California that oil pipelines could move methanol as a product just like it could move other liquid fuels as a product. We have analysis.

When Bechtel did their study, they assumed there would have to be a separate pipeline because the Alaskan Pipeline would be fully occupied. I think one of the issues would be to what extent would oil flowing from Prudhoe Bay and any new finds and any new explorations take up the capacity of the pipeline. Assuming that there was capacity, our study attempted to analyze that.

While it is more expensive than making the natural gas somewhere else because you do not have that transportation cost, it is within $.10 or $.15 of the other sources of supply.

Senator **Murkowski**. Specifically, if I may conclude, the economics have been the major factor. It is generally perceived that it is technically feasible. There is evidently some concern over the corrosion potential of putting this in, but I do not know the significance of that.

I am really concerned with somebody taking a look at the economics to see if the end cost would justify the investment for the liquification and whatever else is necessary.

Is the EPA prepared to do that?

Mr. **Rosenberg**. We will try to do that, and we will ask our associates at the Department of Energy to assist us.

The real important aspect of this bill that drives those economics in part is creating a market. If there is in fact a market for alternative fuels under this Clean Air Bill which is driven, as I pointed out, by the clean air consequences, not necessarily that we want to create an energy market, but it turns out that these fuels clean the air dramatically better than the alternative fuels, then by having a market the economics change the risk of producing the supply of investing and being able to sell change when you have a large market.

We will try to do that analysis for you.

Senator **Murkowski**. When might you have that completed?

The **Chairman**. Why not let him finish and then come back to questions. I do not mind one question.

Senator **Murkowski**. When would it be completed; six months?

Mr. **Rosenberg**. May we answer that in writing?

Senator **Murkowski**. Thank you, Mr. Chairman.

Senator **Ford**. Mr. Chairman, we are talking about natural gas, and we get into all this. I have worried about this for a long time as to when the bubble is going to burst and all that.

Let me just read to you and let you then offset that. A spokesman from the Natural Gas Supply Association of America said that its major producer members favor the use of CNG in fleet vehicles but have not taken a stand on other motor vehicle clean air issues. He said that NGSA does oppose widespread use of methanol for cars because, and I quote, "that would require importing a lot of methanol because we do not have the excess natural gas production to make methanol".

Now tell me about that.

Mr. ROSENBERG. We also support the use of CNG in fleets as they do, and we would particularly expect in the President's program for converting new buses to alternative fuels that CNG would be a very important component. I dedicated with the vice president a bus produced in Columbus, Ohio——

Senator FORD. I understand that, and you are getting away from the question, though. But is the NGSA man right in his judgment about not having enough natural gas?

Mr. ROSENBERG. I would say that most of the methanol with the exception of what is produced in Alaska, if any, will be imported just as most of the incremental gasoline that is going to meet our increased demand will be imported.

Senator FORD. So we are getting to the environment problem by exporting jobs again.

Mr. WILSON. Senator, I think you missed the key part of——

Senator FORD. I missed a lot of things, but it is always missed. When you import everything and you come up here and give us—we have got to get it from somebody else.

Hell, we do not have a program. That is what I said earlier. We do not have a national policy. We come in here with bits and pieces and we do not have—we have the horse before the cart, and it just seems like to me that we always are coming in here with something grandiose and it winds up that we have got to get it from somebody else.

I apologize for—but it just gets to grating me, seeing that we are always trying to put a little something together. We get a PR firm and we get charts and visual aids and all that kind of stuff, and we wind up not having all those parts in a packet that is in the best interests of this country. You are out front with all this, and we do not even have the launching pad ready.

Mr. ROSENBERG. Senator——

Senator FORD. Thank you, Mr. Chairman.

Mr. ROSENBERG. Our final chart relates to some of the other issues relating to health and safety, and I think it is important to note that—and we were asked to comment specifically on methanol here, in your letter—that while methanol, or ethanol, or CNG are different and indeed have health and safety risks, there are not any more and in some cases they are less than gasoline, and that is not to say that they are not serious, but indeed they are, as are gasoline emissions and toxicity, serious.

On the question of toxicity, our research to date shows that methanol vapors are not carcinogenic, unlike, say benzene and other vapors from gasoline. Again, I wish to point out that we are starting a major study to kind of review all of these fuels again and again to understand what we can do to improve them all.

The Health Effects Institute, which is a jointly funded institute between EPA and the auto industry, with Archibald Cox as the Chairman, specifically concluded that inhalation—that is, the breathing of methanol vapors—should not prevent government from encouraging the development and use of methanol fuels, assuming this is in the public interest on other issues.

Methanol is indeed very highly toxic if it is ingested—if it is tasted, if it is drunk—and that is something that maximum precautions are necessary if we are going to expand that.

We believe that is indeed possible. We could put antisiphoning devices on automobiles, additives to affect the taste and smell, and childproof containers. Right now, for example, every service station in America sells methanol in a container. It is called windshield wiper fluid. It is dangerous, and it has a little toxic sign on it, just like the pumps when they sell gasoline have toxic signs on them.

So it is necessary to deal with these precautions, particularly on the siphoning question, and make it virtually impossible for someone to siphon fuel out of an automobile using methanol. Once we do that, we think we can reduce the risk level, and EPA is always interested in the risk level of things, down to a safe level.

Finally, with respect to fires, the Indy 500 cars are used because methanol does not explode. It has a cooler fire and a less severe fire, and with respect to flame color, we believe additives can be added to deal with that problem.

The long and short of this is, there are no show-stoppers in our opinion relating to health and safety risks. The risks are real. All fuels have real risks, and methanol, or ethanol, or CNG, reformulated gasoline or regular gasoline, all have to be handled very carefully.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Rosenberg follows:]

TESTIMONY OF
WILLIAM G. ROSENBERG
ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

October 17, 1989

Mr. Chairman and Members of the Committee, I am very pleased to be given the opportunity to discuss with you the clean alternative fuels program which the President has included in his comprehensive Clean Air Act Amendments of 1989. EPA has had a long-term interest in the topic of clean alternative fuels and I am pleased by the Committee's interest. While I recognize that this topic raises important economic and energy security issues as well, in accordance with your letter of invitation I would like to focus my testimony on the environmental issues associated with clean alternative fuels.

I am sure you are all aware that ozone is our most serious urban air quality problem. While the stratospheric ozone layer protects human life by filtering out ultraviolet radiation, ground-level ozone has been shown to impair lung function and damage lung cells. Based on data from 1986 to 1988, 101 urban areas exceed our health standard for ozone. And unfortunately, many of these areas will not reach compliance without stringent additional control programs.

Ozone is not emitted directly, but is a product of a series of complex atmospheric reactions involving hydrocarbons, nitrogen oxides, and sunlight. Motor vehicles are important sources of both hydrocarbons and nitrogen oxides, and our motor vehicle emission control program has achieved considerable success in reducing these pollutants. Compared to an uncontrolled passenger car in the 1960's, a car produced today will emit approximately 80 percent less hydrocarbons and 60 percent less nitrogen oxides during its lifetime. Unfortunately, however, much of this impressive per vehicle emissions reduction has been offset by the continual growth in number of motor vehicles and number of miles these vehicles travel (CHART 1).

EPA believes that for most urban areas hydrocarbon control is the most promising strategy for reducing ozone levels (in some areas, EPA encourages nitrogen oxide reductions as well). Even with the large emissions reductions of the last two decades, motor vehicles still account for 40 to 50 percent of all urban hydrocarbon emissions (CHART 2). Any comprehensive solution to our widespread ozone problem must involve major reductions in vehicle hydrocarbon emissions.

A second important urban air quality problem is toxic air pollution. Toxic air pollution involves a large number of different compounds emitted by a variety of sources. Motor vehicles account for approximately 50 percent of all toxic air problems (CHART 3). Data recently released by EPA indicate that 2.7 billion pounds of toxic chemicals are emitted into the air each year from large stationary sources. Our upper-bound estimate is that total toxic emissions contribute to approximately 1500 to 3000 fatal cancers annually. Air toxics can also be associated with respiratory disease and birth defects. The most important air toxics from vehicles include particulate matter, benzene, and butadiene.

Our proposed Clean Air Act Amendments, as embodied in H.R. 3030 and S. 1490, address ozone and toxic air pollution in a three-step process (CHART 4). First, there are several control programs that can begin to take effect almost immediately. These include further control of gasoline volatility, the use of oxygenated fuels, improved inspection and maintenance programs, the control of refueling emissions, and the use of clean alternative fuels in transit buses. Second, there are several regulations that we will be able to promulgate fairly quickly but that won't begin to provide major emissions reductions until the mid 1990s. These include, for example, tighter vehicle tailpipe standards, improved evaporative emission controls, and off-highway vehicle emission standards. We believe the combination of the standards we already have on the books and these that we are proposing will bring some of our high ozone areas into compliance by the late 1990's.

But many cities will need further reductions of hydrocarbon emissions in order to ultimately comply with our ozone standard. With gasoline vehicle emission controls becoming very expensive and approaching the technological limit, there are only two basic options. The first would be to restrict automobile use in certain areas. We do not believe the substantial use restrictions that would be required are appropriate or feasible in terms of national regulations. The second option would be to switch to inherently cleaner fuels.

There are several vehicle fuels that are inherently cleaner than current gasoline, such as ethanol, methanol, natural gas, propane, and electricity. We project that each of these fuels could provide approximately an 80 percent or greater reduction in ozone-forming hydrocarbon emissions relative to a gasoline vehicle meeting stringent future emission standards (CHART 5). These large emission reductions are due to two primary reasons. First, each of these fuels yields inherently low evaporative hydrocarbon emissions -- methanol and ethanol because of extremely low volatilities and natural gas and propane because they are stored in sealed fuel tanks on-board the vehicle. Second, the hydrocarbon emissions from these fuels, almost exclusively in the exhaust, are much less photochemically active, i.e., much less likely to form ozone, than hydrocarbon emissions from gasoline vehicles.

These fuels would also provide large reductions in cancer incidences from toxic air emissions as well, on the order of 90 percent or more relative to gasoline vehicles (CHART 6). The major toxic pollutants from gasoline are due either to compounds purposely added to gasoline to increase octane, such as aromatics, which lead to benzene emissions, or to partial combustion of large and complex gasoline compounds, which lead to a number of toxic compounds such as butadiene. Cleaner fuels such as methanol,

ethanol, natural gas, and propane are simpler compounds that do not yield complex by-products or need toxic additives to increase octane.

In order to permit us to reap the emission benefits of these clean alternative fuels, federal requirements are necessary at this time. We believe an appropriate federal program must satisfy the following criteria: 1) the program should be fuel neutral, 2) there must be a match between vehicle and fuel supply, 3) fuel must be conveniently available to consumers, 4) the size of the program must be large enough to permit the utilization of economies of scale with both vehicle and fuel production, 5) the program should be temporary, just long enough to solve the chicken and egg problem of market entry which will allow the new fuel to truly compete with the conventional fuel, and 6) the program should rely on market forces as much as possible.

We believe the proposed clean alternative fuels program satisfies each of these criteria. I would like to briefly summarize our proposal.

The program requires that the most polluted metropolitan areas of 250,000 people or more with ozone levels of 50 percent or more above EPA's health-protective ozone standard be included in the clean alternative fuels program. Based on the most recent ozone data, the following nine cities would be included: Los Angeles, Houston, New York City, Milwaukee, Baltimore, Philadelphia, Hartford, San Diego, and Chicago (CHARTS 7 and 8). Automobile manufacturers would be required to produce, distribute, and sell 500,000 clean alternative-fueled vehicles in 1995, 750,000 such vehicles in 1996, and 1,000,000 clean alternative-fueled vehicles in each year from 1997 through 2004. Vehicles would qualify as clean alternative-fueled vehicles if their emissions met the emission standards that EPA would establish by a rulemaking process. Hence, automobile manufacturers are free to sell any combination of fuel and vehicle technology that meets the standards. EPA would then require the availability of the fuels needed by these vehicles. High-volume service stations in these 9 areas would be required to offer at least one clean alternative fuel for sale beginning in 1995. Under the SIP plan, States with affected metropolitan areas would ensure the effectiveness of the clean alternative fuels program. In addition, EPA would retain the authority to extend the fuel availability requirement to major nationwide corridors when vehicles dedicated to clean alternative fuels began emerging. Market incentives are provided throughout the program in order to maximize flexibility and effectiveness: individual cities can opt into or out of the program, or include more vehicles, if certain conditions are met. Automobile manufacturers and fuel suppliers can meet their requirements through emissions trading and banking and fuel pooling as long as the hydrocarbon and toxics emissions reductions are equivalent to those that would have been achieved with the clean alternative fuels programs.

In a separate requirement, clean alternative fuels would be phased-in for new transit buses in metropolitan areas of 1,000,000 population or more based on the following schedule: 10 percent of sales in 1991, 25 percent of sales in 1992, 60 percent of sales in 1993, and 100 percent of sales in 1994 and later model years.

The size of this overall clean alternative fuels program has been designed to be large enough to permit economies of scale to be utilized in vehicle and fuel production, but not so large as to cause economic dislocations. For example, by 1997 EPA estimates that clean alternative-fueled vehicles would account for about 7 percent of automobile and light truck sales nationwide, but approximately 30 percent of sales in the affected urban areas. And fuel demand would grow quickly in those areas so that by three years into the program clean alternative fuel demand at high-volume service stations would be approaching the level of premium unleaded gasoline. Fuel demand would not grow so rapidly as to diminish petroleum demand, however. Overall petroleum demand, even in the affected cities, would actually grow somewhat as the clean alternative fuel demand would simply offset growth that would otherwise occur in petroleum demand (CHART 9).

I would like to focus briefly on one specific air pollutant -- formaldehyde -- that has received much attention. Formaldehyde is both an ozone-forming hydrocarbon as well as a toxic air pollutant, and so has been accounted for throughout our air quality analyses. Formaldehyde is generated by the combustion of all fossil fuels (gasoline as well as methanol) but, as we have reported, methanol combustion yields higher levels of formaldehyde than the combustion of gasoline. Thus, many are concerned that ambient formaldehyde levels could increase with methanol usage. Actually, we do not expect that this will be the case, for the following reason. Motor-vehicle-related formaldehyde is generated in two different ways: emitted directly through the tailpipe and indirectly as the product of reactive hydrocarbons and atmospheric photochemistry. Compared to gasoline-fueled vehicles, methanol-fueled vehicles generate more of the "direct" kind of formaldehyde, but far less of the "indirect" kind. Therefore, overall, it appears to EPA that overall ambient formaldehyde levels would remain nearly constant, or even decrease, if methanol vehicles were to replace gasoline vehicles (See Chart 6). In addition, direct formaldehyde emissions from methanol vehicles can be controlled to levels comparable to those from gasoline vehicles if necessary.

It is critical at this juncture to point out that one of the principal goals of the President's program is the reduction of toxic benzene exposure due to the high volume of aromatics in gasoline. Exposure from motor vehicle benzene emission accounts for 80 percent of the total benzene risk, and more than one fourth of all air toxic risks from gasoline vehicles. One way to deal with this problem is the use of alternative fuels. In addition to the use of alternative fuels, EPA is exploring standards for gasoline under current authority.

Of course, the clean fuels program cannot succeed unless it works for consumers. Consumers must be willing to purchase clean alternative-fueled vehicles and operate the vehicles on the clean alternative fuels. We recognize that there could be consumer reluctance if the program results in cars with poorer performance or less dependability. For this reason, the program has been designed to minimize consumer concerns. The program will permit the use of flexible or dual fuel vehicles in the early years (CHART 10). Those vehicles are expected to look like and perform as well as, if not better than, dedicated gasoline vehicles. Since only a few parts must be added or changed to convert a gasoline vehicle to a dual fuel vehicle which can operate on any combination of gasoline and alternative fuels, dependability will be unchanged. And, since gasoline can always be used, the buyer of a flexible fuel car need not worry about fuel availability or price. Some consumers would likely be attracted to the very low emissions of these vehicles because the car will be less polluting, but it is likely that many more consumers will be attracted by the better energy efficiency and acceleration performance of clean alternative-fueled vehicles. It must be noted that there is nothing exotic about the use of alternative fuels in motor vehicles. Ethanol is currently Brazil's primary vehicle fuel. Propane is used in several countries such as Japan, Italy, and the U.S. Compressed natural gas is used widely in Italy and New Zealand. Methanol is used in Indianapolis-type racing cars as well as in the many demonstration programs now underway in the U.S. Finally, since automobile manufacturers would be required to manufacture and sell the vehicles, they would have every reason to design, promote, and price clean alternative-fueled vehicles in a manner so as to ensure the desired sales volumes.

Consumers will have assurance of convenient fuel availability, just as they did with the successful transition to unleaded gasoline in the 1970's. The combination of the federal requirement that high-volume service stations provide clean alternative fuel for sale and the State's role to ensure that alternative fuel is attractive to the consumer, should provide the needed public confidence. With convenient fuel availability, consumers should be very willing to purchase clean fuels given their higher octane and improved performance (CHART 11). Alternative fuels are now priced competitively with gasoline and we would expect this situation to improve as alternative fuel demand increases providing for production and distribution economies of scale (CHART 12). If necessary, States could adopt a wholesale fuel sales requirement similar to that imposed on motor vehicle manufacturers to ensure that clean fuels are promoted and priced to ensure their use.

EPA is now devoting serious attention to the health and safety implications of the various clean fuels. The fuel that has received the most scrutiny to date in this regard is methanol. Because of the differences in the physical and chemical properties, the human health and safety risks of methanol are different but not necessarily greater than those of gasoline (CHART 13). Methanol appears to be less of a hazard than gasoline in terms of inhalation. Unlike gasoline, methanol contains no carcinogenic substances and, as already discussed, its emissions by-products involve fewer toxic substances. In a thorough review, the Health Effects Institute concluded that "exposure to methanol vapors is not likely to cause adverse health effects." HEI and EPA continue to support further research and testing, particularly with respect to chronic exposure to low levels of methanol.

Methanol is more of a hazard in terms of ingestion, however, and precautions will be necessary to prevent accidental ingestion, such as through fuel siphoning. It is likely that an inexpensive additive can be used to give methanol a distinctive odor and unpleasant taste. Also, simple anti-siphoning devices can be easily installed in autos designed to use methanol. With respect to vehicle and fire safety, methanol fires are much less likely to occur. When one does occur, it burns less violently than a gasoline fire. The one concern is the invisible flame of a methanol fire in bright sunlight, but research is ongoing to develop an additive for luminosity.

As you are aware, EPA has committed to a series of reports detailing the environmental and economic impacts of the various clean alternative fuels. We have already delivered the report on methanol to the Committee, and we are now in the process of preparing similar reports on ethanol, natural gas, propane, and electricity. We hope to begin a similar report on reformulated gasoline when more information becomes available.

In closing, I would like to say a few words about EPA's perspective on the merits of the different clean fuels. Some have criticized EPA for being "pro-methanol" and the clean fuels program for being a "methanol mandate." This is simply not true. The clean fuels program is fuel and technology neutral; any fuel-vehicle combination (for example, CNG, reformulated gasoline, methanol, ethanol, LPG) that can meet the cleaner emission performance standards can be sold.

It is important to emphasize that gasoline itself may qualify if reformulated in a way to produce sufficient reductions in reactive hydrocarbons. This will mean a large reduction in aromatics, some of which are highly reactive as well as toxic, and an increase in oxygenates or ethers, such as ethanol, MTBE or ETBE, to provide a cleaner octane substitute. Because these components also reduce carbon monoxide, it is entirely possible that the marketplace could produce a hybrid fuel that satisfies in one stroke three separate objectives: reductions in CO, VOC's, and toxic air emissions. In sum, we believe there probably will be more than one fuel used in the clean fuels program, but, of course, that decision will rest with the marketplace. I can assure you that EPA will carry out its responsibilities in a fair and impartial manner.

Thank you for this opportunity to testify on this important issue. I will be pleased to answer any questions that you might have.

CHART 1

What Are We Up Against?

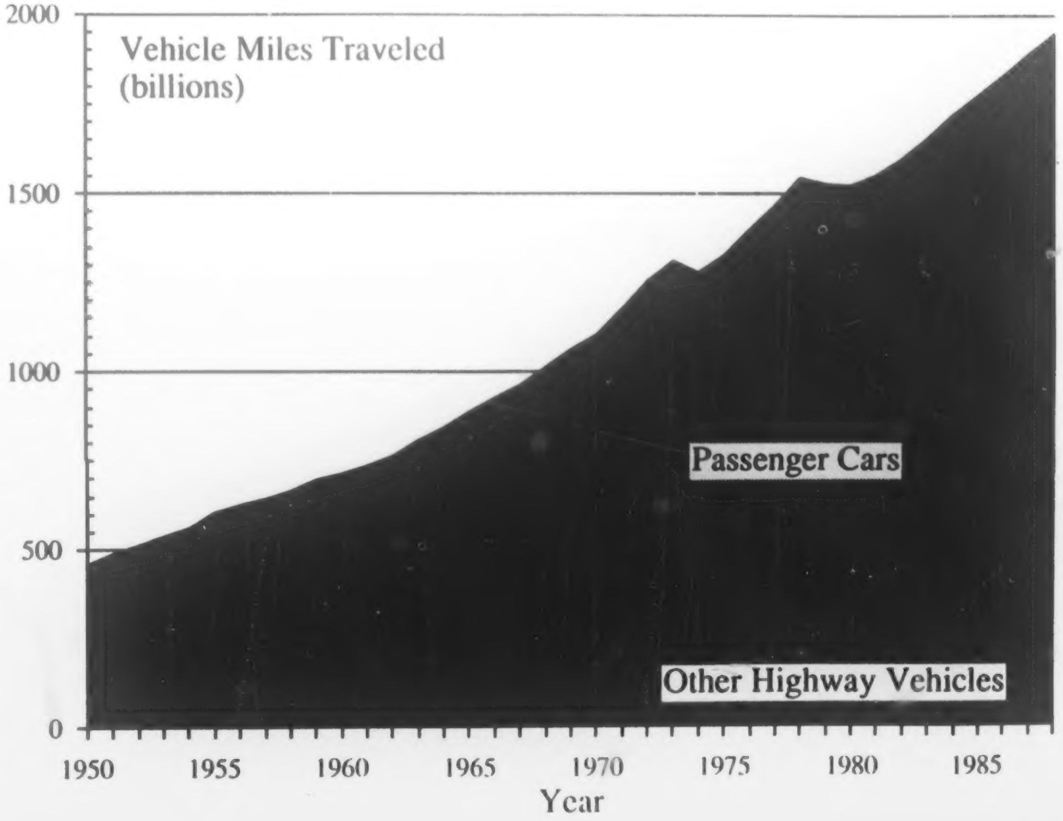
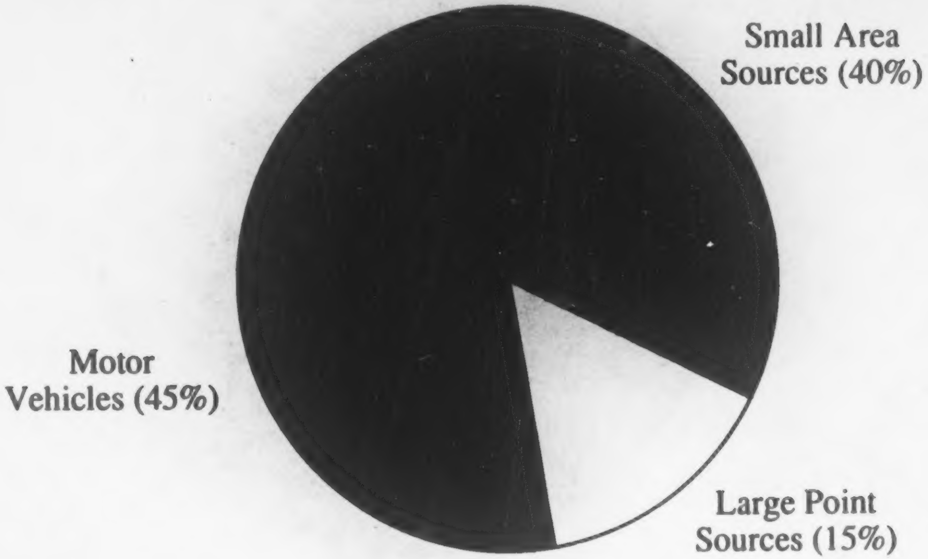


CHART 2

Motor Vehicles Contribute a Large Portion of Urban Hydrocarbon Emissions



Control Options:
- Motor Vehicles
- Small Sources such as Dry Cleaners, Bakeries, and Printers
- Driving Restrictions
- Factories and Other Large Sources

Alternative Fuels Provide Large Reductions at Low Cost

CHART 3

Motor Vehicles are Responsible for a Majority of our Air Toxics Problem

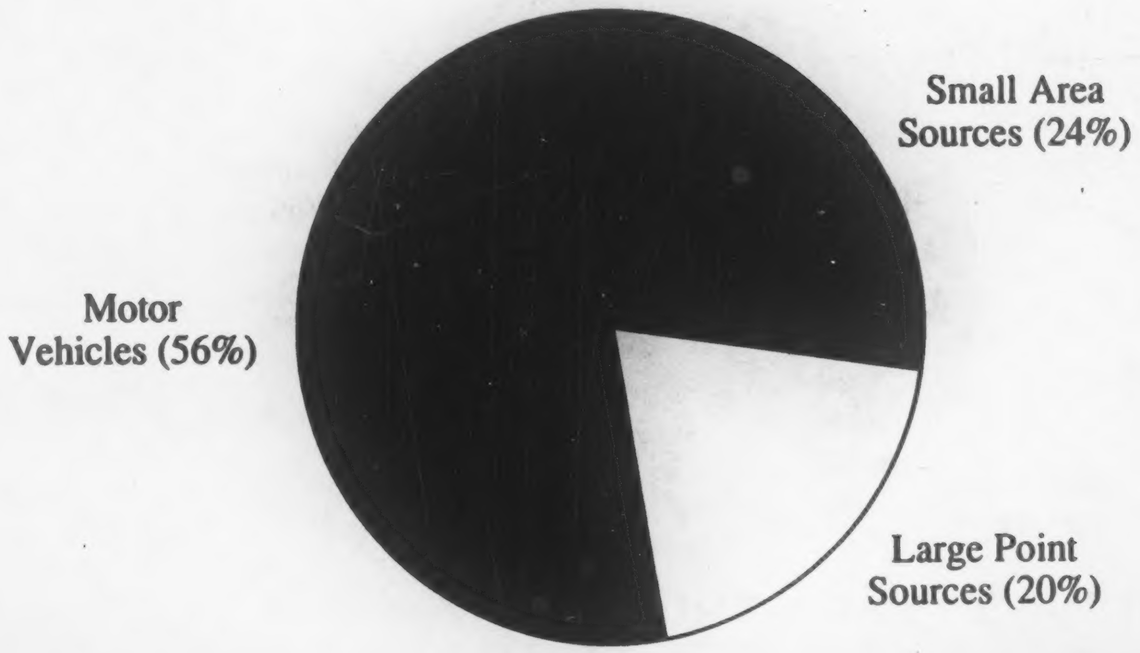


CHART 4

MOBILE SOURCE CONTROLS: THE PRESIDENT'S PROPOSAL

Near Term

- Gasoline Volatility
- Oxygenated Fuels
- Enhanced Inspection and Maintenance
- Refueling
- Clean Fueled Buses

Mid-1990's

- Vehicle Evaporative Control
- Tighter Tailpipe Standards
- Cold Temperature CO Standards
- Diagnostics
- Non Road Engines & Fuels
- I/M Certification Tests
- Diesel Fuel Controls
- Clean Fuels

Post-2000

- Advanced Clean Fuels

CHART 5

The President's Proposal Greatly Reduces Per Car Emissions

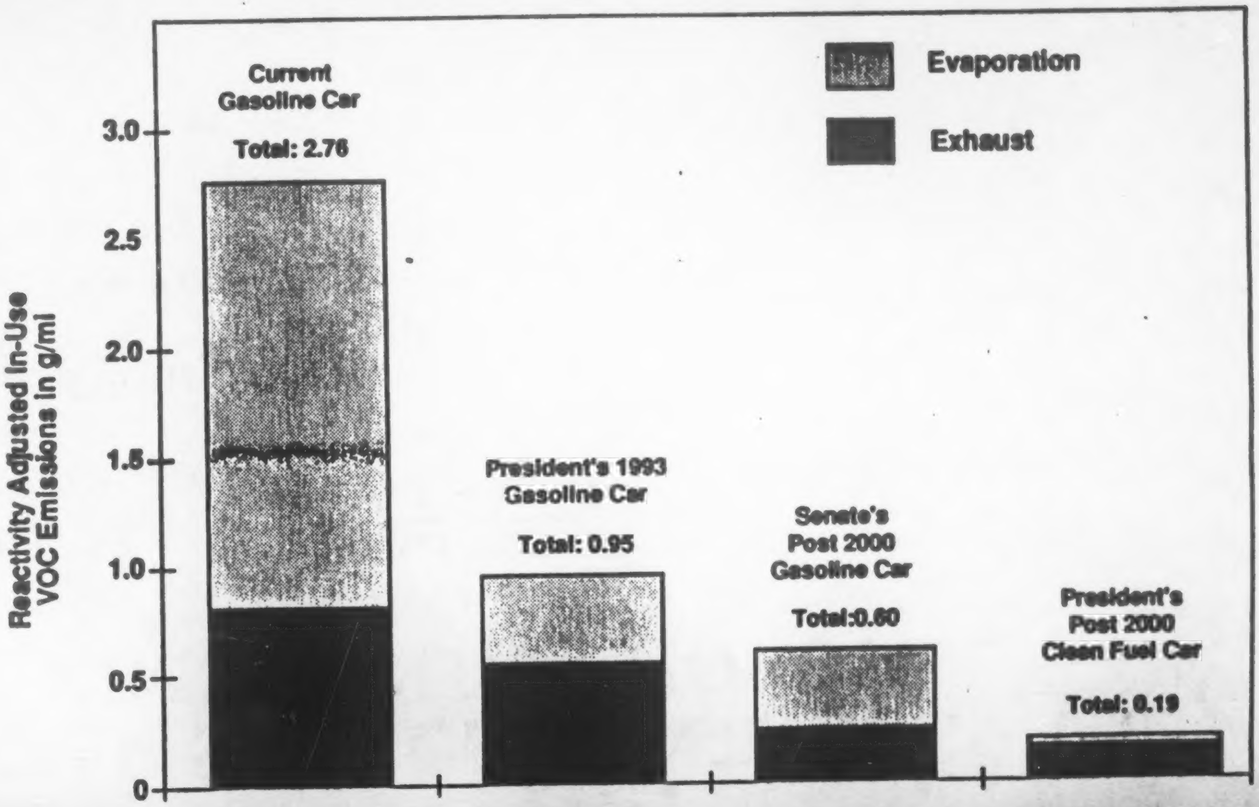
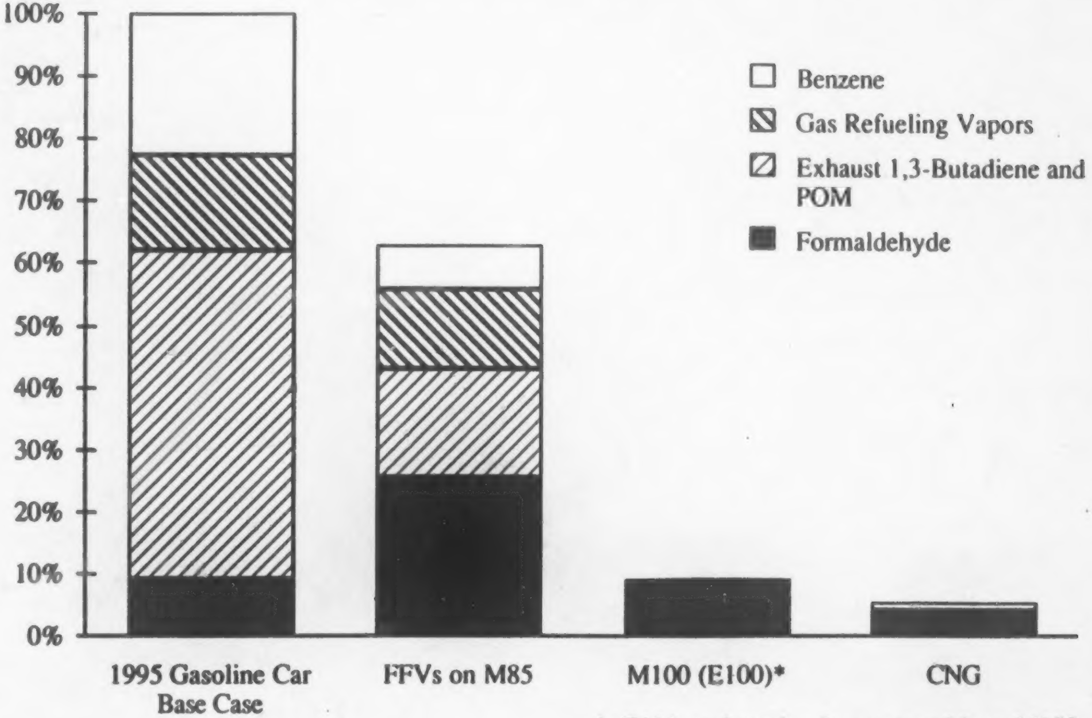


CHART 6

Air Toxics Impact of Clean Fuels



* E100 projected to be comparable to M100

CHART 7

President's Program Will Affect Our Dirtiest Cities

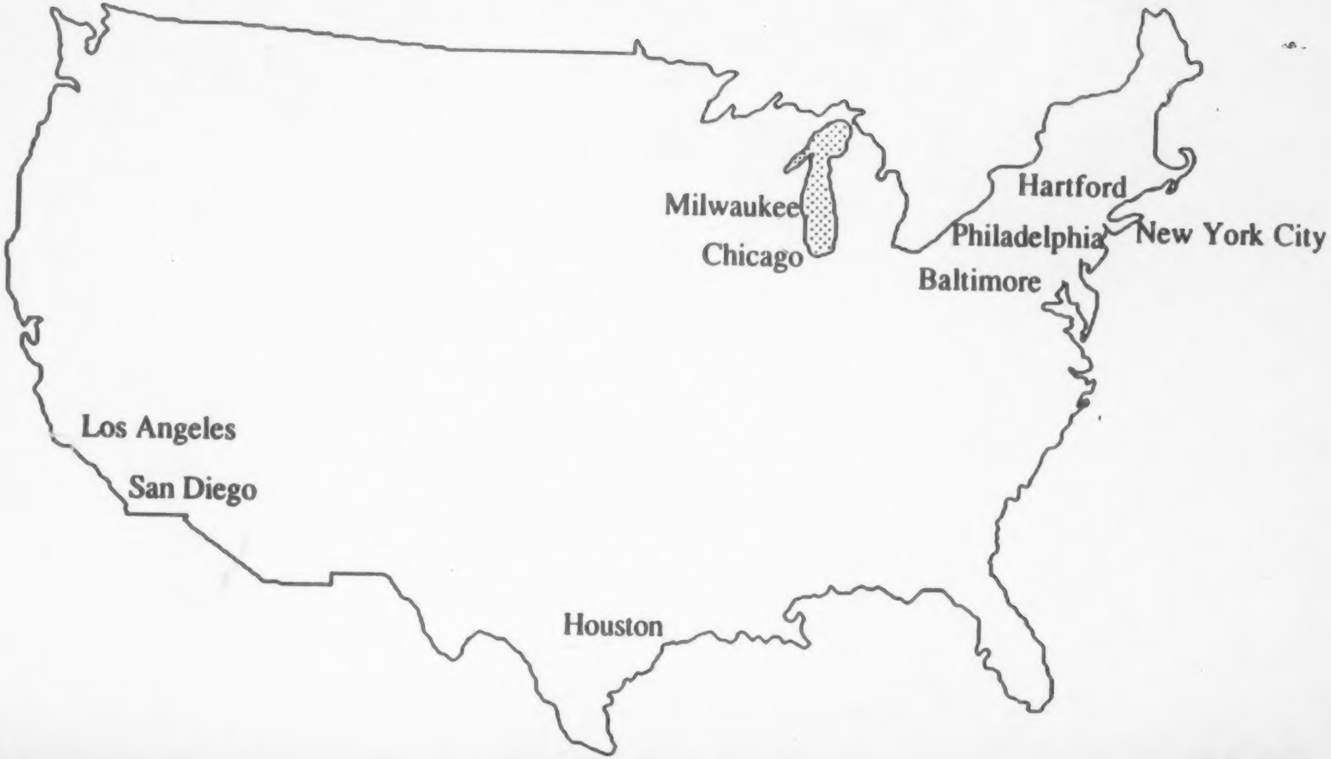

Milwaukee
Chicago
Hartford
Philadelphia
New York City
Baltimore
Los Angeles
San Diego
Houston

CHART 8

The President's Clean Fuels Program is Fuel and Technology Neutral

- 30 Percent of New Vehicles in Dirty Areas Must be Much Cleaner than Other New Vehicles.
- EPA will Promulgate Emissions Performance Standards:

	% Reductions	
	1995	2000
Hydrocarbons	30	80
Toxics	40	90

- Market Based: Industry is Challenged to Meet Standards in the Most Cost-Effective Manner -- Any Combination of Engine and Fuel.
- EPA will Assure that Fuels Match Cars.
- Similar to Introduction of Unleaded Gasoline in the 1970's.

CHART 9

Projected Highway Fuel Consumption Nine Affected Urban Areas

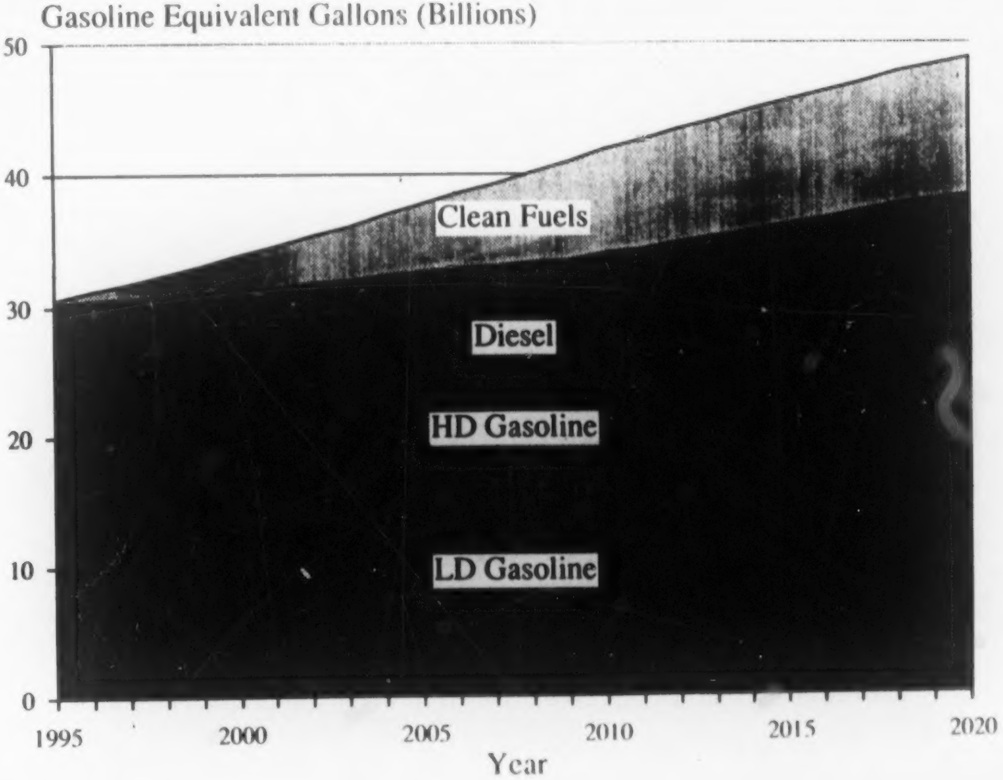


CHART 10

Will Consumers Buy Clean Alternative-Fueled Vehicles?

- Program is Designed to Minimize Consumer Reluctance.
- Initial Vehicles will be Flexible Fuel or Dual Fuel Vehicles.
    - Few changes from gasoline-only vehicle
    - Can operate on gasoline
    - Should perform better on clean fuels
- Fuel will be Conveniently Available.
- Automakers will Design, Promote, and Price Vehicles to Ensure that Required Number of Vehicles are Sold.

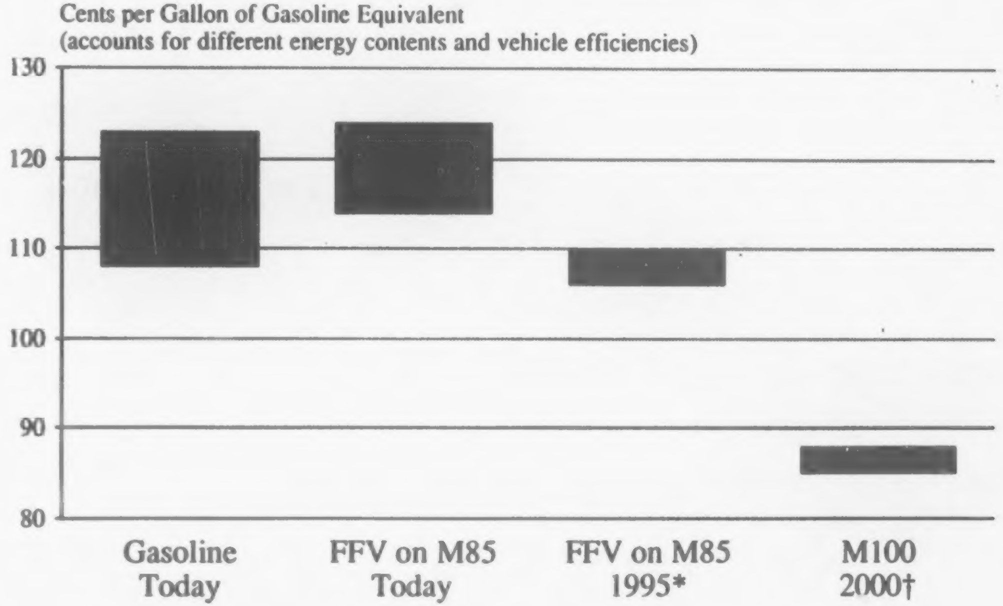
CHART 11

Will Consumers Buy Clean Alternative Fuels?

- Considerable Experience with Clean Fuels in U.S. and Around the World.
- Federal Requirement will Ensure that Clean Fuels are Conveniently Available in Dirty Cities.
- Clean Fuels are Premium, High Quality Fuels Offering Improved Performance.
- Clean Fuels are Projected to be Price-Competitive; If not, States Could Adopt Fuel Sales Requirements Similar to Auto Sales Requirement.

CHART 12

EPA's Methanol Report Shows Fuel and Vehicles to be Economical



* FFVs projected to cost $300 more than gasoline vehicles.

† Dedicated M100 vehicles projected to be equal in cost to gasoline vehicles.

CHART 13

Health and Safety Risks of Methanol are Different, but Generally Less Than Those of Gasoline

- Toxicity
    - Methanol vapors are not carcinogenic.
    - Health Effects Institute concluded that inhalation of methanol vapors "should not prevent government from encouraging the development and use of methanol fuels, assuming [this is] in the public interest."
    - Methanol is highly toxic if ingested; precautions necessary to minimize occurrence.
- Safety
    - Methanol fires much less likely and much less severe.
    - Additives being studied to provide flame color, taste, and odor.

The CHAIRMAN. Thank you very much, Mr. Rosenberg.

Senator MCCLURE. Could I ask just a couple of questions with respect to this chart?

The CHAIRMAN. Why do we not go in order? Mr. Rosenberg, in the House, the Hall-Fields Amendment passed which says that you have to have the capacity to produce these cars. You do not have to actually produce them. Considerably less stringent than the Administration's provision.

Now, there is a lot of confusion as to what the Administration's present stance is. Are you for Hall-Fields, or are you for the original proposal which requires that you have that capacity?

Mr. ROSENBERG. Could I read a statement on that? I figured that question would be asked, and this has been cleared by everybody as far as I know. I spent all day yesterday working on this one.

Senator FORD. Did you convince him?

Mr. ROSENBERG. You tell me after I read the statement.

When the amendment was circulated to the Subcommittee—that is the Hall-Fields Amendment—the Administration raised for consideration adjustments to the amendment that sought to craft a middle ground in two fundamental areas. First, instead of having merely to certify to the capacity to produce, the Administration favored that the automobile manufacturers be required to produce, distribute and offer for sale cars that achieved specified annual emissions reductions.

Second, unless the Administrator determined after a study that there would be no need for further emissions reductions, that technology for obtaining further reductions is not available, or that such reductions will not be cost-effective, the Administrator would establish Phase 2 emission standards based on the use of M100, CNG, LPG, E100 or other such clean fuels.

We are confident that with these changes, the Fields-Hall Amendment will achieve environmental benefits comparable to the Administration's proposal. Until these amendments are made part of the Fields-Hall Amendment, the Administration continues to support the President's original proposal in both the Senate and the House.

The CHAIRMAN. With respect to the cost of methanol, building these plants would be very expensive. Right now, one reason that OPEC's price is low is not because they want to keep their price down, but because there's a huge excess amount of crude oil out there, and in effect some competition.

Now, if we got dependent—I mean, if we manufactured these cars that have to use methanol, and we were dependent on a limited source of these plants in Saudi Arabia or USSR or wherever, why do you have such confidence that the price would not be manipulated through a cartel and be more likely to be manipulated than it is now, since there would be far fewer producers?

Mr. ROSENBERG. I will try two points. First, we would anticipate in the first five years, senator, that there would be dual fuel vehicles, so that in the event there was a shortage of methanol for whatever reason, or the price of methanol were too high, the consumer could operate the vehicle on either gasoline or methanol. So unlike the gasoline situation, where there is a monopoly, here there is some choice.

The **Chairman**. That is during the first five years?

Mr. **Rosenberg**. Well, we do not know that they will not continue to have the capacity beyond that, but certainly in the foreseeable future.

We expect the economics will be driven by the availability of flared and vented natural gas that is now being wasted, and that is very broadly dispersed around the world. The very large supply, for example, in Trinidad.

The **Chairman**. But you have to build the gathering lines for that. That is not as cheap to—you cannot just take that vented gas. You have to build a lot of infrastructure for that, do you not, and then clean it up and all of that?

Mr. **Rosenberg**. But that is all built into the Bechtel analysis, what it would cost to in fact produce those plants. We think that—and the Department of Energy will be more specific on this, but there is a very broad availability of natural gas, much broader than of oil, I am told, and there is certainly a very broad availability of flared and vented natural gas around the world, so we would not see that the production of these facilities would be all concentrated as intensely in the Middle East. I understand that——

The **Chairman**. Most of the vented gas, the biggest supplier of that is the USSR, is it not?

Mr. **Gray**. No. The associated gas combined, the Middle East and the Soviet Union and East Bloc countries represents less than 20—or, about 20 percent of the available associated gas. The other 80 percent is dispersed in more favorable parts of the world.

The **Chairman**. Libya, Egypt, Algeria——

Senator **Ford**. They do not have the money to build these plants, unless we are going to fund them.

Mr. **Gray**. We have been contacted by several, for example Brazil, Australia——

The **Chairman**. Let me move to another thing. I asked you initially and you did not really answer the question about the old cars, and I have the figures that old cars account for only 50 percent of the mileage, but it looks like about 90 percent of the CO_2 and about 92 percent of the HC and about 80 percent of the NO_X. Does that not suggest that whatever we do on methanol, whatever we do on that, that we ought to do something about reformulated gasoline and give that a very high priority? Is that not a cheaper, higher target of opportunity than anything else?

Mr. **Rosenberg**. Under the bill, we do reformulate the gasoline. If you notice, we talk about reducing fuel volatility, improving oxygenated fuel, improving inspection and maintenance programs. There is no question that it is necessary to improve the quality of the gasoline. In fact, one of the first things that Bill Reilly did when he became Administrator in February was to issue the first order for low volatility fuel in a two-phased effort, so we do expect, for example, in the first point in the near term, to require gasoline volatility to be reduced and to reformulate gasoline as part of the normal process of proceeding forward.

The **Chairman**. Two more questions. First, with respect to price, do you assume that there will be any subsidization? You have such confidence on this price. Do you assume there is no subsidy?

Mr. **Rosenberg**. That is correct.

The **Chairman**. California is really going to require methanol. That is very clear. Why do we not let California do it, determine what their experience is, before we launch off into what could be a revolutionary and perhaps very expensive proposal?

Mr. **Rosenberg**. We recognize that Los Angeles has a problem, but so does Chicago, Milwaukee, Baltimore, Philadelphia, New York, Houston and Hartford, and so the program is designed to provide significant environmental benefits in those areas.

By not spreading it around the entire country, we concentrate a 4 percent to 7 percent of the vehicle sales Nation-wide in these areas it becomes 30 percent of those areas, and we can get between 9 percent and 24 percent reduction in emissions from vehicles in those areas in the first and second phases.

We think that California has provided leadership in this area, but that the problem is just as severe for people living in Houston and Chicago as it is in California.

The **Chairman**. One final question. The Administration proposal is viewed as being tilted toward methanol, even though it is said to be energy-neutral. Actually, you have a lot of discretion there as to whether you would use M85 or require 100 percent. How can we be certain that you will not tilt this thing, because you can obviously define it in such a way as to require methanol?

Mr. **Rosenberg**. Well, sir, we tried to explain, and perhaps you might even put this in legislation, that the way it is going to work is, we are simply going to set performance standards and allow the auto makers to choose any combination of technology.

The **Chairman**. I know, but you can design those performance standards to require methanol, can you not?

Mr. **Rosenberg**. Well, we do not think we have. What we are attempting to do is simply say that there would be a 30 percent reduction in emissions, and we are confident that the oil industry, which is now working on reformulated gasoline, will come up with alternatives that we do not know about.

The **Chairman**. Well, we know that reformulated gasoline does not achieve 100 percent methanol standards.

Mr. **Rosenberg**. We do not know in the future what it could do, but certainly for the first phase we think that 30 percent is a target that can be achieved. It is a combination of technology on the car and the fuels. It is not just the fuels.

The **Chairman**. Can you not design under your proposal a fuel standard that fits only methanol? You do not know whether methanol will ignite at 100 percent or whether it will work, but you know that no other fuel can meet that and you have the discretion to do that.

Mr. **Wilson**. The only real uncertainty now is exactly what reformulated gasoline can do. We know that CNG and LPG and pure ethanol, in addition to pure methanol, all can achieve the same kind of ozone and toxic benefits that we have been talking about, so really there is a wide range of fuels that can do that. As I said, the one thing we are not sure of is just how far you can go with reformulated gasoline.

Mr. **Rosenberg**. But under the President's bill there is the concept of fuel pooling, so that if in fact the overall benefit for using 30 percent of the cars would be a 24 percent overall benefit, because it would be 30 percent times 80 percent, the President's bill does allow the oil industry to come in and say, if we were to reformulate all the gas, or have some combination of reformulated gasoline and some of these alternative fuels, we can get an overall benefit in the communities equal to the reductions you are seeking on a small portion of the fleet.

Under the President's bill they have that opportunity to come in and say, on an average, we can get just as much air quality benefit as you might want us to get on 30 percent of the fleet, and so that is what makes it fuel neutral under the proposal.

The CHAIRMAN. Well, I will not pursue that because my time is up. Perhaps some of the other senators would want to do that. I am going to have to go over and handle my amendment, so Senator Ford, if you can preside, or Senator Rockefeller?

Senator FORD. I am not going to ask any questions, but I may ask just one. When you say pure ethanol, and methanol, and so forth, how in the world can you control the price on any of it?

Ethanol is out of the business today and a lot of plants are being closed down because of the price of corn and so the plants are closed. There is not a drop of ethanol coming out. It is being used by one major company.

How in the world can you look in your crystal ball and know that everything is going to be status quo out there and the price is going to come down and all of these good things?

Mr. ROSENBERG. We do not know for sure, but we do know what the cost components are to make some of these fuels, and I would agree that ethanol is very expensive and might not be competitive in the short term until there are some new processes developed, without any government subsidy of course.

But we have attempted to compare the projections of gasoline with reasonable projections of methanol and CNG and think that those two fuels will be competitive in the future. There is no reason why they should not, but we do not know for sure.

Senator FORD. Well, the only reason that ethanol was kept going, I guess, is because of tax subsidy, otherwise it would not have been out there anyhow.

Mr. ROSENBERG. The real reason we want to do this, Senator, is that really these fuels clean the air and compared to other things we have to do to clean the air, even if we are off by orders of magnitude, it is less expensive to use alternative fuels than, say, require all the bakeries around to have stringent controls, or to reformulate all the points to get the same amount of reductions.

The Clean Air Act is a zero sum game, as I said before, and if we do not get the reductions from motor vehicles we are going to have to put further restrictions on our industries, on our small businesses, that could affect our competitiveness, and it would be more expensive for the society.

Senator FORD. I have no problem, Bill, with agreeing that that is where it has to come from, but I just am concerned about, earlier, that we do not have an overall strategy. Nothing is working in tandem.

Everybody is out here grabbing their piece of it and we are not saying this is what is projected and we are going to put that into place and everything works in tandem. We are just not doing that, and that concerns me and the Near East in my opinion, you said they only have 20 percent and everything else is friendly, but if we do not fund them or give them foreign aid or something, they are not going to build.

The Near East probably is the only area that is going to have the kind of funds to go ahead and move, and so not only will they then control both sides, they will control LNG, they will control the oil, and manipulate us just like they want us.

I am not for that. I am going to have to be more than convinced that that will not happen in order to support an area in which I think the greatest potential is to eliminate and help clean air.

So with that I will turn it over to Senator McClure.

Senator McClure. Thank you very much, Mr. Chairman.

First of all, if I understand it, your testimony today was confined primarily to methanol?

Mr. Rosenberg. That is correct.

We would be prepared to have similar testimony on ethanol and CNG; and reformulated gas, at this point, is an unknown to us. So we do not know what that is.

Senator McClure. So your concentration on methanol today is a result of the request, not a result of any bias as far as you are concerned?

Mr. Rosenberg. That is correct. And we hoped we have shown that the standards we establish will be standards that all of these fuels can achieve.

Senator McClure. Now, is it not also correct that although that is true, that you are not necessarily here today testifying on behalf of methanol to the exclusion of other alterative fuels, that the standards that you set, the 1995 standards and the year 2000 standards, are precisely those attained by methanol?

Mr. Rosenberg. No. We believe that they could be attained by any of these fuels that we mentioned equally easily. As a matter of fact, CNG is probably a cleaner fuel than either ethanol or methanol.

Senator McClure. Do you have the same background data and statistical analysis and engineering backup for other fuels as you have for methanol?

Mr. Rosenberg. We do not have the same level, but we are producing a report by the end of November that would give us that data.

Senator McClure. If I understand your testimony correctly to this point, it would be clear that the major methanol source would be foreign?

Mr. Rosenberg. Yes, sir, foreign natural gas.

Senator McClure. Foreign natural gas. So that, to the degree we build an added dependence upon methanol, it is a foreign dependence that we are building?

Mr. Rosenberg. Well, not necessarily. Senator Murkowski and I had that conversation about the availability of gas in Alaska.

Senator McClure. I know, but you also said the Alaskan natural gas conversion to methanol would yield a market price for methanol that was higher.

Mr. Rosenberg. Only slightly, sir.

Senator McClure. Well, what is only slightly? Are you talking about 2 or 3 percent or 15 or 20 percent?

Mr. Rosenberg. Probably 10 or 15 cents.

Senator McClure. Ten or 15 cents?

Mr. Rosenberg. That is right, about 10 percent. And that really is speculative as to what——

Senator McClure. So if Alaskan methanol is to compete, it either has to have a subsidy or favorable treatment or it will be underpriced by foreign sources?

Mr. Rosenberg. That is correct.

Senator McClure. Unless you put a big label on it that says "Now help our friends in Alaska, please buy Alaskan methanol."

Mr. Rosenberg. Unless, of course, the foreign sources increase their prices, which is what Senator Ford was concerned about.

Senator McClure. Well, I suspect that they will do as they are doing in oil, and that is, do their best to find a price that just keeps other alternatives from the market, but as high as they can get it short of that.

Mr. Wilson. Senator, if I might inject.

Senator McClure. Sure.

Mr. Wilson. You know, all our data suggests that the new refineries required for the increased gasoline demand in this country are likely to be also offshore and the gasoline will be imported. Unfortunately, we may be facing a choice of one import versus another.

However, in the long run——

Senator McClure. I would advise you in that instance to consult your friends in the Department of Energy, if indeed you have some there, and I assume you have.

Mr. Wilson. We have. You can ask them the same question.

Senator McClure. I will. Because one of the points that needs to be made is that foreign producers of oil are investing in downstream facilities in this country.

Mr. Wilson. But one of the points I was trying to make was, eventually, we know how to produce both ethanol and methanol from biomass and other materials in this country.

Senator McClure. All right. That is my next question. You have talked totally about methanol from natural gas. How about methanol from other sources?

Mr. Rosenberg. Well, I think the most attractive environmental source would be biomass, because that would clearly have the most positive global warming implication. I know of your interest in the ethanol industry, and we share that.

In this bill, for example, on the oxygenate fuel requirement, we have attempted to create a much broader market for the use of ethanol as an additive to gasoline to reduce carbon monoxide. We would expect that with the introduction of a major new market for alternative fuels, that would stimulate more economic activity in research and development in the biomass area, which could be grown in this country, to provide feed stock that is grown.

And one thing we can do in this country is convert solar energy very well into carbohydrates through our farms.

Senator McClure. Let me ask this question. Have you made the comparison in feed stock costs and operating costs between natural gas as a feed stock and coal as a feed stock?

Mr. Gray. We have looked at that, but I think the Department of Energy will be addressing that later in their testimony. Our analysis is similar to theirs in suggesting that remote natural gas, unless those countries, as Mr. Rosenberg suggested, decide they want to try to increase the price of the gas or the methanol, then, first, Alaskan methanol would become the most competitive. And there is more than enough gas being reinjected in Alaska to support this program, too.

So the first step, if it is left to, so to speak, the free market, would be Alaskan gas. And if an energy policy, somewhere down the road, evolved that suggested it be made domestically, then you would have several options, but at a somewhat higher price. But in that time frame, petroleum may be at that same somewhat higher price, too.

Senator McClure. Well, petroleum may follow the price up, as a matter of fact. That would be my expectation. Petroleum would not drive, but would respond to the price and increase their margins.

If I understand correctly what you are saying, you are talking about 30 percent of the automobiles within a market have to have certain mandated features with respect to their fuels?

Mr. Rosenberg. Right, 30 percent.

Senator McClure. Why did you adopt a per-vehicle standard, rather than a fleet standard?

Mr. Rosenberg. Well, we thought about it the same way because basically we are asking the auto makers to make the decision as to what technology and what fuels they wish to use.

Most of the clean air standards are in the statute on a per-vehicle, so this is just consistent with the way in which the Clean Air Act actually works.

Senator McClure. Well, there are some other alternatives. For example, electric automobiles.

Mr. Rosenberg. They would qualify.

Senator McClure. Well, they obviously qualify, but they qualify much more and yet there is only a per-vehicle standard. And therefore even though they qualify much more in reductions than anything else, they get no more credit.

Mr. Wilson. The President's bill provides for additional credit based on how well the vehicle does. So if an electric vehicle, for example, did twice as well, it would count as two vehicles.

Senator McClure. Then you could market one of those and two dirty ones?

Mr. Wilson. That is right.

Mr. Rosenberg. Well, two less clean.

Senator McClure. I guess that is what we are talking about here.

Mr. Wilson. Senator, the size of the program is critical. To reach economies of scale in both fuel and vehicle production, you need to have sufficient demand, otherwise the program can be quite expensive.

Senator **McClure**. Let me ask this question with respect to cold climates. Is there not a problem with methanol fuels in cold climates?

Mr. **Wilson**. There is absolutely no problem with the M85 fuel that would be sold during the first several years of the program.

Senator **McClure**. No problem in starting the automobile?

Mr. **Wilson**. No. That is one of the reasons why the gasoline would be included in the methanol.

Mr. **Rosenberg**. But there is a problem for the M100 that has to get resolved. That would not go into effect until the year 2000, and that provides a long lead time to achieve that solution. But the M85, which is 15 percent gasoline, does start equally well in cold weather.

Senator **McClure**. May I ask that the memo, which was sent to you, Mr. Gray, from Mr. Hellman on this subject, be made a part of the record at this point.

[The information referred to follows:]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR AND RADIATION

July 6, 1989

MEMORANDUM

SUBJECT: Preliminary Test Results From the Nissan Sentra Methanol-Fueled Vehicle

FROM: Karl H. Hellman, Chief, CTAB

TO: Charles L. Gray, Jr., Director, ECTD

This memo contains the results of the testing of the prototype Nissan Sentra methanol-fueled vehicle to date, a comparison of the results from the methanol-fueled car to comparable gasoline-fueled cars, and a discussion of the test plans for the vehicle for the immediate future.

Preliminary Test Results

The Nissan Sentra vehicle is a prototype vehicle configured to run on M100 fuel. Its specifications are listed in Attachment A. The vehicle represents Nissan's latest effort in a high efficiency, good performance, low emission M100 package.

Emission and fuel economy test data from tests run at our laboratory are shown in Tables 1 and 2.

Table 1

M100 Nissan Sentra Emission Test Results
(g/mi)

HC	CH3OH	HCHO	CO	NOx
0.01	0.38	0.031	0.43	0.57

Table 2

M100 Nissan Sentra Fuel Economy Test Results
Gasoline Equivalent MPG

City MPG	Highway MPG	55/45 MPG
37.0	52.0	42.5

During our evaluation of the M100 Nissan Sentra, a persistent cold transient driveability problem developed several months ago. A series of diagnostic tests have been performed and the results given to Nissan. Some parts have been replaced which did not eliminate the problem. We continue to work with Nissan to resolve this problem.

Comparison to Gasoline-Fueled Vehicles

One of the aspects of the data from this prototype car that has generated the most interest is the fuel economy performance. The fuel economy of the M100 Sentra will be compared to the fuel economy of a comparable gasoline-fueled car three different ways in this overall project. Two ways to compare the MPG have been completed. Different ways to compare the results are necessary because, as is the case with most unique prototype vehicles, there is not a gasoline-fueled vehicle that is an exact match for the M100 prototype. With M100 vehicles the acceleration performance is usually better than the gasoline-fueled car and sometimes the test weight is also different. Making a comparison is usually a combination of test results and mathematical adjustments to the data to account for differences not accounted for in the testing.

The First Method, Method A

The first comparison we made was the comparison of the M100 results to the nearest match on the EPA test car list for 1987, since the M100 Nissan Sentra is based on a 1987 model year car. This resulted in the identification of the Nissan Pulsar as the gasoline-fueled vehicle that matched the M100 Nissan Sentra the best. The M100 Sentra and the production gasoline Pulsar use the same basic engine and the same transmission type. The Pulsar was heavier than the M100 Nissan Sentra, however, and had a slightly different road-load horsepower value. This is shown as comparison A1 in Table A. We next closed the differences by testing the M100 Nissan Sentra at the same weight and road-load horsepower as the gasoline-fueled car. This is shown as comparison A2 in Table A. After the testing was completed, the match was still off with respect to N/V ratio.

The last comparison in method A was to use mathematical adjustment of the MPG values to account for the N/V difference. The data from the M100 Nissan Sentra was adjusted using N/V sensitivities of 0.21 and 0.43 for city and highway MPG, respectively. This is shown as A3 in Table A.

Table A

Comparisons of a M100 Nissan Sentra MPG to a 1987 Nissan Pulsar from the Test Car List

				Dyno		Gasoline Equivalent MPG			Percent
Method	**Fuel**	**CID**	**ETW**	**HP**	**N/V**	**City**	**Hwy**	**Combined**	**Difference**
A1	Methanol	110	2250	7.3	44.4	37.0	52.0	42.5	+46%
A1	Gasoline	110	2875	7.1	53.6	25.0	36.7	29.2	--
A2	Methanol	110	2875	7.1	44.4	36.8	53.8	42.9	+47%
A2	Gasoline	110	2875	7.1	53.6	25.0	36.7	29.2	--
A3	Methanol	110	2875	7.1	53.6*	35.3*	49.4*	40.5*	+39%
A3	Gasoline	110	2875	7.1	53.6	25.0	36.7	29.2	--

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* Adjusted mathematically to infer results if tested at 53.6 N/V. The N/V result of 44.4 was measured at EPA. Nissan provided information that the N/V was 43.7.

The Second Method, Method B

The next step in the process was determined to be the comparison of the M100 Nissan Sentra to a gasoline-fueled Nissan Pulsar using test data for both MPG and performance determined using the same chassis dynamometer. Nissan was contacted and they agreed to loan us a gasoline-fueled Nissan Pulsar from their fleet for our testing. In addition to MPG, acceleration performance was determined using 5 MPG to 60 MPH accelerations on the chassis dynamometer as the measure.

In addition, EPA had the M100 Nissan Sentra modified to incorporate the same final drive gear ratio (4.167:1) as the gasoline fueled Nissan Pulsar. For this comparison, therefore, the N/V ratio would be matched almost exactly with tire diameter differences being the only source of a difference in N/V. After the modification, the M100 Nissan Sentra was much faster (at 9.6 seconds) than the gasoline Pulsar (at 12.7 seconds). We plan to rerun this data to confirm it. The gasoline-fueled vehicle used for this series of tests was not the same vehicle as was used for generating the data from the test car list.

The test data comparison shown as B2 was made after the final drive gear ratio change was made. Comparison B3 was made with an adjustment to the data to account for the performance difference.

Production Vehicle

Table B

Test Results of a M100 Nissan Sentra and a 1988 Gasoline Fueled Nissan Pulsar
(Preliminary Data)

Method	Fuel	CID	ETW	Dyno HP	N/V	Gasoline Equivalent MPG City	Gasoline Equivalent MPG Hwy	Gasoline Equivalent MPG Combined	Percent Difference
B1	Methanol	110	2875	7.1	44.4	36.8	53.8	42.9	+52%
B1	Gasoline	110	2875	7.1	53.3	23.9	36.7	28.3	--
B2	Methanol	110	2875	7.1	54.0	32.6	46.7	37.7	+33%
B2	Gasoline	110	2875	7.1	53.3	23.9	36.7	28.3	--
B3	Methanol	110	2875	7.1	54.0	--	--	43.2*	+53%
B3	Gasoline	110	2875	7.1	53.3	23.9	36.7	28.3	--

* Adjusted to account for the difference in performance with a sensitivity value of 0.454.

The Third Method, Method C

In their guidance to EPA on the comparison testing done to te, Nissan favored a different test approach. Instead of sting and modifying the M100 Nissan Sentra to match the N/V of the gasoline fueled Nissan Pulsar, Nissan would prefer to supply EPA with another Pulsar vehicle that EPA could modify to have the gasoline-fueled Pulsar match the M100 Nissan Sentra's N/V.

EPA has asked Nissan to proceed with the procurement and break-in of the next gasoline fueled Nissan Pulsar, and we plan to install the M100 Sentra transmission with its original final drive gears installed in the next gasoline fueled Nissan Pulsar. After the next set of performance and fuel economy comparison tests are run, Nissan would like both vehicles returned to their original configuration and we plan to do so. We also will continue to try to resolve the driveability problem with the M100 Nissan Sentra and we plan to rerun some test sequences when the problem is resolved, as a check on the data generated with the driveability problem.

Attachment: M100 Nissan Sentra Specifications

Attachment C

M100 Nissan Sentra Specifications

Vehicle	Sentra B-12 U.S. model
Inertia Weight	2,500 lbs.
Test Weight	2,250 lbs.
Transmission	Manual 5-speed
Engine model	CA18DE (modified)
Cylinders	In-line four
Compression ratio	12.0:1
Displacement	1.8 liters
Bore x stroke	83 x 83.5 mm
Fuel system	Multi-point electronic injection
Catalyst type	Monolith
Catalyst volume	1.7 liters
Engine oil	7.5w-30, low friction
Camshafts	Dual overhead
Ignition system	Four coil direct
Fuel injectors	Two hole electronic
Pistons	Two-ring and Mo coated for low friction
Intake manifold features	Swirl control valves
Valves	Four per cylinder
Induction	Naturally aspirated
Valve overlap	"Narrow"
Valve lift	"Low"
Valve springs	Low friction
Excess Air Ratio	1.5 during typical FTP conditions

Senator ROCKEFELLER. Senator McClure, have you completed your questions?

Senator MCCLURE. I have just a couple more, one, with respect to health effects. One thing you did not show in your chart is the health effect of absorption through the skin. You have, I think, some information with respect to that. And would you tell me what that information is?

Mr. GRAY. Certainly. That is one of the areas that has been researched quite extensively. Methanol used to be the principal solvent for paints, in fact, so there is a tremendous amount of what we call case study evidence to establish some human dose response information.

And although there is a different variation among susceptibility to individuals, if one were to soak one's clothes in methanol for several hours, then you could absorb enough methanol to be potentially quite dangerous.

Senator MCCLURE. You are saying getting it on your hands or on your skin, other than the incident you have mentioned, soaking your clothes in it, has no adverse health effects?

Mr. GRAY. Well, it is a good thing to avoid. But I just happened to notice this weekend in my child's chemistry set that the fuel they recommend for the little fuel burner is methanol because it is the safest of the fuels that they can provide in that context.

Senator MCCLURE. Again, I am not asking a comparison at this point, because we just knocked alar out of apples over something far less dangerous than alcohol fuels.

Mr. GRAY. You should avoid skin contact because it can be absorbed, but it takes a significant amount of exposure and duration of that exposure before you can absorb enough to have an impact.

Senator MCCLURE. I sure wish EPA were as tolerant of a lot of other things as you seem to be about the dangers of methanol.

Mr. GRAY. But you would certainly not want to subject yourself——

Senator MCCLURE. Maybe we ought to transfer you to another division and get some cross fertilization of ideas within EPA. [Laughter.]

Mr. GRAY. I think we have a very strong sense of concern about public impact, and for that reason, not just 10 years, but for 20 years we have studied this. And we feel that in comparison to not changing, we are living with a very toxic substance called gasoline. And in comparison, it would clearly be safer and less toxic.

Senator MCCLURE. Well, that was another one of the health effects that I wanted to talk about, because you say methanol is highly toxic if ingested. And that is true of gasoline too, is it not?

Mr. GRAY. Yes, but along the line of being concerned about something that we are suggesting, or promoting, if you will, we think that we need to make all prudent efforts to avoid ingestion of methanol because it is an alcohol, it is not an immediate poison, it takes about 24 hours. And in a sense, that is an advantage and a disadvantage, because there is time for treatment, but people might not get the treatment if they do not see an immediate response.

So there are some measures that we have committed to implement that would reduce the risk.

Senator McCLURE. I am not suggesting you are not concerned about health effects, I am just trying to draw some comparisons to the other health effects that are in the marketplace today for the fuel we now use.

Mr. ROSENBERG. Senator, the API has this, you have probably seen this on all the gasoline stations, and this is what it says. This has been distributed by API, and in Michigan at least, it is on most of the stations. And when you look at fuel, it says:

> Health warning: Use as a motor fuel only. Harmful or fatal if swallowed. Long-term exposure to vapors has caused cancer in laboratory animals. Avoid prolonged breathing of vapors. Keep face away from nozzle and gas tank. Keep away from eyes and skin. Never siphon by mouth. Failure to use caution may cause serious injury or illness.

That is gasoline. And that is on every gas tank, I think, in the District; it certainly is in Michigan. I do not know if it is nationwide, but that is what you have to compare it to.

And so we think that, on balance, these alternative fuels will not be any more toxic, but, in fact, will probably be less toxic than the gasolines.

Senator McCLURE. Thank you very much. I have some other questions I will submit for response in writing.

Senator ROCKEFELLER. Mr. Rosenberg, as I understand your response to Senator McClure, what you are basically saying is that whether we use methanol, which will be, in its first instance, imported in the form of natural gas, or in fact from our own flared or reinjected natural gas, which we have in Alaska, or whether we use gasoline, both are going to be imported?

Mr. ROSENBERG. That is correct, sir.

Senator ROCKEFELLER. And those are points that are never made together: Both are going to be imported. But there is a difference, and the difference is that methanol, as it is fed by natural gas, imported, is decentralized, and therefore will never have the cartel effect that OPEC has.

So that the effect of methanol, in terms of importing, is far less severe and certainly without the potential for coordination that OPEC has, in terms of setting prices. Would you not agree?

Mr. ROSENBERG. Yes, indeed.

Senator ROCKEFELLER. And would you not agree also that as methanol, in the form of natural gas, is imported from overseas, that that inevitably serves as a bridge to the making of methanol and the development of methanol in this country?

Mr. ROSENBERG. That is correct, from either biomass or gas or, ultimately, coal, if we can see how to do that without causing other environmental problems.

Senator ROCKEFELLER. Let me ask this. The OTA is going to testify here, if we ever get to them, that the air quality benefits that can be achieved from reformulated gas is more cost-effective than with alternative fuels. Do you agree with that?

Mr. ROSENBERG. Well, I mean, I do not know what the air quality benefits are that can be achieved from reformulated gas until the oil industry tells us what reformulated gas is.

Senator ROCKEFELLER. Well, not only agreeing with that, do you know of any tests that have been made, with respect to reformulated gas, that tell us anything about any of this?

Mr. ROSENBERG. Well, the only reformulated gas that we have seen is what ARCO has done in California. And I would say there, that the reformulated gas there would not provide the same environmental benefits that the alternative fuels would have. They have indicated that they are going to develop another reformulated gas.

Senator, I do not think the words "reformulated gas" existed in this context until the President proposed his challenge.

Senator ROCKEFELLER. I thoroughly agree with that. It was a suddenly emerging fuel that took a lot of us by surprised.

Would you not also agree that even if reformulated gas, and you and I do not agree that it would, but even if it were more cost effective than alternative fuels, that would still not preclude us, as a matter of public policy, from pursuing alternative fuels?

Mr. ROSENBERG. Well, we should do both. But if it is more cost effective than under the bill, the auto companies would select that, rather than an alternative fuel, and meet all the environmental requirements.

So we view this as a challenge. And if in fact reformulated gas, which may be some combination actually of methanol or ethanol and gasoline, as I understand the reformulated gas in California has MTBE in it, for example, if, in fact, that is the best way to go, then we would hope that is the way we would go. And we would not seek any barriers to that.

But the standards should be the standards we can achieve. And that is why the standards we placed up there are those that we think can be achieved with the fuels we know about, and hopefully might be achieved on a more effective basis with some other fuels.

Senator ROCKEFELLER. Would you not agree that in the creation of public policy, and you have just mentioned MTBEs, that there ought to not be a differential. in terms of tax treatment of ETBEs and MTBEs?

Mr. ROSENBERG. Well, I think the administration does support the differential, with respect to ethanol, that exists at this point.

Senator ROCKEFELLER. Now the folks from ethanol point out that that is a much cheaper fuel, but of course what they do not point out is that they have a substantial tariff which controls the price, or allows the price to rise, therefore. And, to me at least, that is a factor. You do not have to comment.

With respect to global warming, those who criticize methanol often refer to the effect on global warming. Of course what they are assuming is that as soon as methanol is used it will be made holistically from coal. And there is this vast prejudice about methanol, on the part of at least some, on the assumption that it is a matter of coal. They sort of conveniently neglect that the first part of it is going to be natural gas.

For what period of time do you suppose that natural gas will be the principal methanol beneficiary? Or, asked another way, when do you think that coal will become a majority factor on methanol?

Mr. ROSENBERG. We have no way of estimating when coal will become competitive, either in price or in the environmental implications in the global warming issue.

Senator ROCKEFELLER. But you have a sense. I mean Chevron, for example, estimates it will not take place until the year 2050.

Mr. **Rosenberg**. Well, we would not think it would take place any faster than that.

Senator **Rockefeller**. Well, that is depressing.

Mr. **Rosenberg**. It really depends, though, on the research and development that is done. I do not know what research and development is being planned. I think you will have to ask the Department of Energy, on their R&D program, what their estimates would be.

Senator **Rockefeller**. Well, they will say 2010.

Mr. **Rosenberg**. We will accept their judgment.

Senator **Rockefeller**. All right.

So, in any event, I have been told that even with current technology, coproduction of methanol and electricity produces less CO_2's than separate production of electricity and gasoline. Does that not help, in that respect, to mitigate global warming?

Senator **Bumpers**. What was that question?

Senator **Rockefeller**. That even with current technology, coproduction of methanol and electricity produces less CO_2's than separate production of electricity and gasoline?

Mr. **Rosenberg**. Well, if that is true, then that would deal with that problem, just like cogeneration of power.

Senator **Rockefeller**. That would mitigate global warming?

Mr. **Rosenberg**. Yes, it would.

Senator **Rockefeller**. Some of the oil companies have said that the President's bill tilts towards methanol, and it has been mentioned here this morning. I am not aware anywhere in the language of the bill where that is the case, are you?

Mr. **Rosenberg**. We take very strong exception to that. We believe our bill is going to establish performance standards that would allow any of the alternative fuels that are on the scene to compete.

From an environmental point of view, if they can all achieve it, it becomes an economic decision. It would challenge the auto companies to develop technologies to use those fuels, and we have seen that it has challenged the oil companies to develop plans to produce reformulated gasoline.

We think it has done a pretty good job so far. And if it gets enacted, we think that will be a market challenge to both of these industries to clean up the fuels in a cost-competitive way.

Senator **Rockefeller**. I just have a final question and two others that I will submit to you.

Every time that we have a hearing, and I alluded to this before, and there is any discussion of methanol, there is automatically a lot of talk about formaldehyde. And of course you never hear about benzene in gasoline, in terms of carcinogenics and that kind of thing.

Now why do you suppose that is, Bill?

Mr. **Rosenberg**. Well, it is an advocacy position. I do not know why. I only say that it is inaccurate. When you look at air toxic emissions from vehicles, you have to look at all the ones that cause cancer, not just one.

And as you can see on the chart, formaldehyde is not the majority, by a long shot, of the problem. It is a problem. It has to be dealt with. But you need to compare the overall problem of cancer-related incidences, and that is the analysis we do at EPA. This analysis that has been available to the public for a long time. This is not the first time we have discussed it.

But those that are advocating against alternative fuels have chosen only one small part of the analysis.

Senator ROCKEFELLER. And to follow up on that, is it not true that the amount of toxic pollutants with gasoline, far exceeds the toxic emissions with methanol, including formaldehyde, right there?

Mr. ROSENBERG. Obviously.

Senator ROCKEFELLER. Just say yes.

Mr. ROSENBERG. Yes.

Senator ROCKEFELLER. Thank you. [Laughter.]

"Right there" does not show up on the record.

Is it not also true that formaldehyde from methanol vehicles can be reduced to the levels of formaldehyde from gasoline when you take into account what it is that people never talk about; that is, the secondary reaction, not just the tailpipe emission but the secondary reaction?

Mr. ROSENBERG. There is indeed technology that is available to do that, and one of the leaders in developing that technology is Mr. Gray here. If you want to get any more information about that, we would be pleased to discuss it.

There is a tremendous amount of research, hard on-car research being done at the EPA Labs in Ann Arbor that confirms that point.

Mr. WILSON. Senator, the third bar there for M100 shows equal formaldehyde to a gasoline vehicle.

Senator ROCKEFELLER. Right. Those do not show up in the record. I think Senator Domenici was next.

Senator DOMENICI. Thank you very much, Mr. Chairman.

Senator Murkowski, are you on a short time frame?

Senator MURKOWSKI. Go ahead.

Senator DOMENICI. Let me first say I have no particular bias one way or the other. I would just like to make sure that we do not start down a path only to find that we have failed to make certain assessments either of the marketplace nature or of an environmental nature and that we get down here about five or six years and the euphoria is gone when we have either a new risk assessment, we have something very bad that we did not otherwise have or that it is not working in the marketplace and we start a whole new program of having to subsidize one fuel over another, in which event it would seem to me if you are going to do the latter you sure ought to subsidize, if you ever do, in favor of becoming less dependent upon foreign sources rather than more.

So let me ask if you would just fundamentally start by telling me what you were trying to do with this program. Simply, what are you trying to accomplish?

Mr. ROSENBERG. We are trying to reduce the amount of air pollution in the nine U.S. cities to demonstrate how that can be done economically and to lay the groundwork for a policy decision at the end of the decade, at the beginning of this century to determine if this is economically and environmentally as good as we think it is going into it.

Senator DOMENICI. Now I assume that since you are trying to develop alternative fuels at this point that at least for the beginning part of this program you are not trying to develop alternative fuels that necessarily minimize America's dependence upon foreign sources of energy for our lifestyle, because in the early parts it is kind of admitted that one of the major thrusts would be methane, and we cannot competitively produce that for quite some time.

Is that a fair assessment?

Mr. ROSENBERG. Not fully, Senator. Remember, one of the fuels that we think will play a big part will be compressed natural gas——

Senator DOMENICI. We hope so.

Mr. ROSENBERG [continuing]. Which will particularly be useful in fleets with the essential fueling facilities such as bus transportation and fleets like the Post Office. We are attempting to provide whatever support we can to the gas industry to make sure that they get a fair share of the activity. We have spoken to the auto industry. We have done research in our labs to make natural gas.

So to the extent that compressed natural gas particularly in fleets and buses and heavy duty vehicles can play a role, that would most likely be the Texas, Louisiana and other pipeline gas.

With respect to the liquid fuels——

Senator DOMENICI. But if we wanted to do that, we could also approach that from another angle not only of the nine cities but, rather, create some incentive for fleets and the like to go ahead and get more natural gas burning engines on the market, could we not? That would be another way to move that?

Mr. ROSENBERG. That is correct, but it is very important to recognize that to make the cars effective or the trucks cost effective you need a big enough market to get the economies of scale.

We had originally proposed 2 million cars, and Dr. Boskin at a hearing with the Department of Energy and us reduced it down to 1 million.

If you are just going to have fleets by themselves, we think that is a very expensive way to go because you will not have the economies of scale; but if you have a fleet program as well as a passenger vehicle program that is large enough to get the economies of scale, then both the fleets and the passenger program will work.

Senator DOMENICI. Let me move on. I do not want to take too much time, as there are other Senators. I have a couple of points I would like to try to make.

Let us go back to your point. You are trying to clean up the air in nine dirty cities, cities that have very high ambient pollution levels, and one way you chose was this 30 percent alternative fuels that you are going to try to push.

Now was there another alternative totally separate and aside from that for those cities?

Mr. ROSENBERG. There are many other things we are doing, too, Senator.

Senator DOMENICI. I do not mean that.

Mr. ROSENBERG. At the margin, to get pollution under control from vehicles, the choices are really restricting driving, which we felt politically and publicly we did not want to do—

Senator DOMENICI. Clean up the cars more?

Mr. ROSENBERG [continuing]. Or push technology harder at a much more expensive cost than using alternative fuel technology.

In fact, we were concerned that because the technology on the cars has gotten so clean, which is the way I started my testimony, an 80 or 90 percent reduction since the uncontrolled cars of the 1970s, it would cost much more to further tighten the technology without consideration of also cleaning the fuels.

Senator DOMENICI. Now let me just pursue it from that point.

So you have elected on behalf of the President of the United States to opt for an alternative fuel approach within these most polluted cities, and now we are talking about will it work; do we have the mechanisms for the marketplace to adjust to it. People are not going to pay more for one fuel as opposed to another. A few might, but essentially if it is 10 or 15 cents higher and you have alternative engines you ought to put it in your model and you will probably get only 10 percent of the result. Probably 90 percent of what you expected is gone.

You do not intend that the states in your answer to one of the Senators' questions could literally force the price accommodation so that it would be economic? Did you mean that in an answer?

Mr. ROSENBERG. Yes, I did mean it.

Senator DOMENICI. So you are actually saying that you would expect a state in the United States that has one of these situations to say we are going to have the same price for gasoline as we have for this new product, and somebody is going to make up the difference?

Mr. ROSENBERG. A state has to achieve their ambient air quality goal in a variety of ways——

Senator DOMENICI. Yes, I understand that.

Mr. ROSENBERG [continuing]. And it has many enforcing mechanisms. One which the bill gives them is the ability to, for example, require distributors to sell a certain percentage of the fuel that they sell to be alternative fuels if that is what they want into the marketplace. That is no more coercive than saying to a utility plant they have to put a scrubber on the utility plant.

There are, indeed, State initiatives comparable to what we would ask them to do under this bill.

Senator DOMENICI. Please do not misunderstand. I am not yet saying that I would be unalterably opposed to that. I am merely trying to get to the point that this is not going to work unless it works in the marketplace.

Mr. ROSENBERG. I might give you a marketplace number, too.

If you were to try to reduce the cost, say, 10 cents per gallon on an alternative fuel, that would only require a one cent per gallon increase on gasoline because there will be so much more gasoline around.

Senator DOMENICI. I understand, but I have great reluctance to get into that kind of pricefixing even in the terms of a good result because I never know the consequences. Things like one cent, I am just kind of queasy about that being the way to get it done.

Let me move on, because these other Senators need to ask questions.

I think the next issue that I would like to raise is as we attempt to make this partial clean-up of a fleet, what is the effect going to be on imported cars?

Mr. ROSENBERG. All sales vehicles from importers as well as domestic would have to get the same ratios. Let us assume that the ratio that was determined in a given community by EPA was 30 percent. Anybody selling a car would have to have credits for 30 percent.

Now they could trade them and bank them, but every distributor of vehicles would have the same requirement whether they were imported or not. Now if they were largescale imports from, say, Germany or Japan, they may in fact put the same thing on the cars. If not, they are going to have to acquire credits from other major manufacturers in order to sell their vehicles.

So there is no bias in favor of importers at all under the program.

Senator DOMENICI. What is going to happen if the populace just does not respond to your 30 percent allocation and they just will not buy these cars?

Mr. ROSENBERG. Well, we had the same problem, I guess, with the CAFE standards where the auto companies are obligated to have a certain average fuel economy, and on occasion they have to subsidize the small cars because they want to sell large cars.

We think that in this case it is up to the auto manufacturers to develop market strategies, pricing strategies, and, as I mentioned to Senator Rockefeller, his CAFE credit will prove more than the adequate incentive for them to do that, that the cost of producing these additional devices may be $200 or $300. The CAFE credits are worth three or four times that, so they have every financial incentive to price the cars without taking a loss.

Senator DOMENICI. Mr. Chairman, you said I used six minutes. How much are we supposed to use?

Senator ROCKEFELLER. Well, Senator, I just have to say because of the malfeasance of some of the rest of us if we give to each witness the attention that we have given to these, our committee will adjourn at 8:30 p.m. tonight.

There are three more Senators. Senators Conrad and Murkowski each have a question, and I do not know about Senator Bumpers. Senator Murkowski is next in line.

Senator MURKOWSKI. Thank you. I will be brief as we move right along.

Senator DOMENICI. I had one last question.

Have you done a risk assessment on the ingestion potential? What happens if we have a spill of this compared to what we currently import in terms of the assessment?

Mr. GRAY. Spill and ingestion are two risks we have assessed. In the case of spills, because of certain desirable features that relate to methanol in particular, we think that would be a significantly less ecosystem impact, environmental impact.

As we said earlier, we think we need to implement certain restrictions, regulations that will ensure that ingestion risks are less than they currently are for gasoline, and our analysis suggests that that can be done relatively easily.

Senator DOMENICI. Thank you, Mr. Chairman.

Senator Rockefeller. Senator Murkowski.

Senator Murkowski. Thank you, Mr. Chairman.

Are you gentlemen familiar with a proposal that was around a year or so ago called the Spike project which proposed to take gas liquids, butane and propane, through the Trans-Alaska Pipeline mixed with the oil and then being pulled out at Valdez and exported?

My question is specific. That required a preprocessing prior to flowing through the pipeline. With your recommendations on the potential market of methanol, is it technically feasible to consider a liquefication plant that would have the capability of handling dual products so you could address the economics in a more favorable manner by producing butane and propane, moving them through with the oil and then sending segments of methanol separately because of the tremendous availability of gas?

Mr. Rosenberg. Senator, we have done no analysis of that, but we can try to do that analysis with the other question you asked us.

Senator Murkowski. I would appreciate your separating them and doing one analysis on the basis of a facility that would produce methanol alone, recognizing you have a certain economic realization, and then the additional convertibility to be able to produce butane and propane as well as methanol because it may address more favorably the economics of lowering the unit cost of methanol to be more competitive with foreign gas sources.

Mr. Rosenberg. Senator, this is an area that I think requires analysis by ourselves and others, and you might ask that question of others that come before this committee.

Senator Murkowski. I intend to, and the time frame you indicated——

Mr. Rosenberg. I will have to get back to you.

Senator Murkowski. Are we looking at years, light years?

Mr. Rosenberg. Hopefully soon.

Senator Murkowski. Soon as relative?

Mr. Rosenberg. I do not know. I would like to take a chance and speak to our experts to see what capacity we have and then get back to your office in the next couple of days.

Senator Murkowski. You do feel you have the capability in house?

Mr. Rosenberg. We have some consultants that we work with. I do not know what our capabilities are on that specific issue, but I will get back to your office in the next couple days.

Senator Murkowski. Before the next election? [Laughter.]

Thank you, Mr. Chairman.

Senator Rockefeller. Senator Burns.

Senator Burns. I have just a couple of comments. I think you have probably heard my comments at the top end of these hearings.

I would just want to caution you because of who you are and who you represent. Your main goal is to clean up those nine cities. I would caution you as to setting policy before we start cleaning up, because I have just come out of a Small Business hearing up there about regulatory reform. Sometimes we set regulations, and I have the same concern as Senator Domenici. Sometimes we do not set policy until we get into something, and we really do not know where we are heading.

So I would say adjust your thinking a little bit. Maybe we should set the policy and then implement it.

Mr. **ROSENBERG**. Senator, the Clean Air Act has been debated for the last ten years, as you know. There has been a stalemate and, unfortunately or fortunately, these things do interrelate.

This is work that is not something that has just been thought about. As Mr. Gray indicated, we have been working on it for a long time.

Senator **BURNS**. Are you familiar with the process of burning coal slurry as a replacement in diesel engines? Are you familiar with that?

Mr. **ROSENBERG**. Mr. Gray is.

Senator **BURNS**. Okay, just so you are familiar with it. That is about all I have. I would just caution you on that. Underground storage is part of that scenario of implementing policy bass ackwards so to speak.

Senator **ROCKEFELLER**. Senator Bumpers.

Senator **BUMPERS**. Mr. Rosenberg, what is the current best cost estimate of producing methanol from coal?

Mr. **GRAY**. Before I answer——

Senator **BUMPERS**. Are you Mr. Gray?

Mr. **GRAY**. I am.

I would like to preface the answer to enhance my credibility by saying that I am from Arkansas. With a little practice——

Senator **BUMPERS**. You will get no hostile questions from this Senator. [Laughter.]

Mr. **GRAY**. Once I get into it, I will be able to communicate even more effectively, too.

We have certainly looked at methanol production from coal over the last 15 to 20 years. It was a major consideration of Bill Ruckelshaus as a way to provide an alternative market for high sulfur coal as he looked at strategies to control acid rain. The Department of Energy has researched this quite extensively, and all of these analyses come out quite similar.

For a dedicated plant, the methanol price would be probably 50 to 60 percent higher than this low-cost remote natural gas. If oil prices grow as they are now predicting using the Department of Energy numbers, however, that could very well be competitive after the turn of the century.

It would take something beyond environmental policy, in other words energy policy, to provide the market for coal-based methanol in the foreseeable future.

Cogeneration is the one area that the Department of Energy has done a lot of recent work in which does show more favorable economics.

Senator **BUMPERS**. Mr. Gray, you mentioned apparently natural gas is by far the best and most efficient and cheapest way to produce methanol; is that correct? You say it is roughly 50 percent cheaper than coal?

Mr. **GRAY**. Based upon our analysis, the wide variety of available natural gas around the world that has no other market would be the lowest cost feedstock for these plants.

Senator **Bumpers**. What is that cost?

Mr. **Gray**. What is that cost?

Senator **Bumpers**. With today's technology.

Mr. **Gray**. Our projection is on a gasoline energy equivalent basis with the transition vehicle, that is just a little over a dollar per gallon gasoline equivalent. With the dedicated methanol vehicles, it is a little less than 90 cents per gallon of gasoline equivalent.

Senator **Bumpers**. So we are talking about with coal $1.40, $1.35, $1.45?

Mr. **Gray**. In that range, yes.

Senator **Bumpers**. Now what is the energy input of making methanol from coal compared to energy output?

Mr. **Gray**. That, of course, depends on the efficiency. Since it is a chemical conversion process, current technology would be on the order of 60 percent, maybe as high as 70 percent thermally efficient in that conversion because the feedstock is, on an energy basis, quite low in cost so you do not put more capital, more investment, to improve the efficiency because you are just reducing the amount of low cost feedstock.

Senator **Bumpers**. What are the carbon dioxide emissions in converting coal to methanol either in the process or in the burning?

Mr. **Gray**. Coal has, of course, a high carbon to hydrogen ratio, and because of that, all other things being equal, the utilization of coal produces more carbon dioxide.

The key question is, how do you dispose of it? In a coal to methanol process, unlike other ways of using coal, the carbon dioxide is inherently already concentrated. If the coal is burned, it becomes a small percentage of the combustion gases, and it becomes very expensive to scrub it out and then have the option to dispose of it in someplace other than the atmosphere.

So in the long, long term the opportunity to take this concentrated stream of carbon dioxide from a coal to methanol plant and dispose of it in an environmentally acceptable manner other than to the environment is certainly a feasible consideration.

Senator **Bumpers**. Where are we technically on our ability to scrub carbon dioxide?

Mr. **Gray**. In the methanol to coal process, it inherently is scrubbed from the stream because you do not process the carbon dioxide over the methanol since it is a catalyst. So you scrub the carbon dioxide inherently in that process. It is already in a concentrated gas stream, and then the decision is do you vent concentrated carbon dioxide or do you dispose of it by injecting it into depleted oil reserves or something of that sort in capping the wells.

It will cost something if we want to minimize the carbon dioxide impact in the long, long term of coal utilization, but from our analysis it is the means of using coal in the long haul that would result in the lesser impact on global warming of any option we have seen.

Senator **Bumpers**. Apparently one of your reports says that gasoline and methanol mixed act synergistically to increase the rate of methanol absorption into the skin.

Are you familiar with that? Mr. Rosenberg, maybe that is in your category?

Mr. **Rosenberg**. Yes. There have been a couple of studies that looked at this.

First of all, methanol is a polar compound much like water, so it is not effective as a grease remover, including natural human oils or greases. For that reason, we would not expect people to store it around their home as they do gasoline because some people still use gasoline as a solvent around the home. Methanol would not be suitable for that.

When you add gasoline to methanol and then it gets on your hands, the gasoline is what dissolves the oils in the skin, and then it reduces one of the barriers——

Senator BUMPERS. It opens up the skin, then, to the reception of methanol?

Mr. ROSENBERG. It removes one of the barriers to the absorption of methanol into the body, that is correct.

Senator BUMPERS. Has EPA considered what impact that would have, for example, on garage mechanics who are going to be working with this stuff?

Mr. ROSENBERG. Yes, we have. Because of the long duration and requirement for extensive body exposure to this liquid, we think that, although we need to include warnings such as those which currently exist for gasoline, that is not expected to be a significant health problem.

Senator BUMPERS. At the Indianapolis 500 they use nothing but methanol, is that not right?

Mr. ROSENBERG. That is right.

Senator BUMPERS. Who is the biggest manufacturer of methanol in this country?

Mr. ROSENBERG. Certainly in this country it used to be duPont, but now it has shifted outside of this country, unfortunately. The world's largest manufacturer is Celanese, now owned by a German company. About 6 billion gallons of methanol per year are made. It is the 19th largest volume chemical in the world, so there is a vast amount of experience at handling methanol.

Senator BUMPERS. Have they had any trouble, for example, in handling methanol, mechanics and drivers and so on, at the Indianapolis 500?

Mr. ROSENBERG. Because of its improved safety characteristics, about three years ago they did get very sloppy and there was a significant fire in the pit area.

If you have been to a pit in an Indianapolis 500 race situation, they have a very big hose where they need to dump 20 gallons of methanol or 40 gallons, actually, when it is empty into the car in just a very few seconds. So they have a huge hose with a big gate valve. At that time they did not shut the gate valve. When they pulled it out, several gallons of methanol went all over the vehicle. It did ignite in that case. They put the fire out, and the car continued in the race.

Of course, that would not have happened with gasoline, but if you abuse it you can eventually get it to ignite. So although it is safer in a crash and it is harder to ignite, we still have to have certain precautions in its use.

Senator BUMPERS. Thank you, Senator.

Senator MCCLURE. Mr. Chairman, might I ask just one more question for the record?

Senator ROCKEFELLER. The Ranking Member may proceed.

Senator **McClure**. The comparisons you get need to be made very carefully on the record with respect to comparisons of prices. When you compare the price of methanol fuel with gasoline fuel, the gasoline fuel at the pump has a lot of taxes, and the price you are giving is before tax.

Mr. **Gray**. No, sir.

Mr. **Wilson**. It is the same taxes on a per mile basis.

Senator **McClure**. On a per mile but not on a gallonage basis.

Mr. **Wilson**. Sir, otherwise you would end up with a lot more tax revenue. We assume the same tax revenue.

Senator **McClure**. So you are talking about methanol fuels at 90 cents including all the taxes that gasoline now has?

Mr. **Wilson**. Yes.

Mr. **Gray**. Used in a vehicle that is optimized for methanol to get the 90 cents because of the efficiency advantage. It is about $1.10 for a car that has only about a 5 percent efficiency advantage.

Senator **Rockefeller**. Gentlemen, I would like to thank you very much. It has been very helpful.

I call now to the witness table Ms. Linda Stunt, Deputy Under Secretary for Policy and Analysis, Department of Energy, and Dr. Robert Friedman of the Office of Technology Assessment.

I would like each of you to do no more than three minutes of testimony, and I really will interrupt. Then we will have questions.

Ms. Stuntz, we will begin with you.

If we could have order, please, in the hearing room.

STATEMENT OF LINDA G. STUNTZ, DEPUTY UNDER SECRETARY FOR POLICY, PLANNING AND ANALYSIS, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. CARMEN DiFIGLIO, ACTING DIRECTOR, OFFICE OF POLICY INTEGRATION, AND EDWARD R. WILLIAMS, DIRECTOR, ENVIRONMENTAL POLICY

Ms. **Stuntz**. Senator, as we have heard this morning, methanol is one of several alternative transportation fuels identified in the Alternative Motor Fuels Act of 1988 and is one of several candidate clean fuels for the President's proposed clean fuel program.

Its similarity to gasoline has allowed it to be used with relatively few changes to existing vehicles. This is one of the reasons why methanol is so frequently mentioned.

The technology now exists to mass produce fuel-flexible vehicles, those that can burn either M85, 85 percent methanol and 15 percent gasoline, or gasoline by as early as model year 1993. DOE has studied the production and use of methanol extensively as well as other alternative fuels as a way to reduce U.S. dependence on imported oil.

The transportation sector accounts for two-thirds of U.S. oil use, and it is almost entirely dependent on oil; therefore, alternative fuels may hold the promise of significant potential to reduce U.S. dependence on imported oil. That is why the Department has studied it and has issued a series of reports described in my testimony.

Depending on demand for methanol use over the next decade, we do expect that it will be produced from foreign plants that are located near low cost supplies of natural gas. Depending on various assumptions, and there are many reasonable assumptions that could be made about any one of these components, methanol can be produced over a cost range that goes from roughly under 40 cents per gallon to over 50 cents per gallon using current technology. Using potentially available advanced technology in larger scale plants, and given a greater world market for world methanol, these costs could be reduced significantly.

After the year 2000 DOE research hopes that methanol produced from coal and from biomass would be able to compete with methanol produced from gas, although we are not about to put a year on it right now.

There are large sources of natural gas in the Western Hemisphere as well as in Africa, Asia and the Middle East, as we discussed this morning.

Even if the President's clean fuel program were fulfilled using only methanol, which we do not believe will occur, the amount of methanol required could be provided by a wide variety of producers, including those in Central and South America. Gas reserves in this region, in this hemisphere, are quite large in relation to the foreseeable demand for methanol in the next 10 to 15 years.

Methanol produced from natural gas would have slightly favorable impacts on greenhouse gas emissions, although not substantially. The use of flared or vented gas to produce methanol would increase the benefits in terms of greenhouse gas emission reductions since methane itself is a greenhouse gas.

Methanol produced from coal would increase carbon dioxide emissions substantially. We estimate this to be about 40 percent. As you pointed out earlier, Senator, cogeneration opportunities exist to reduce carbon dioxide emissions from coal-derived methanol.

We have provided in the testimony submitted for the record estimates of the amount of methanol that would be required to satisfy 100 percent of the President's program requirements for the nine cities, although we do not believe that methanol or any other candidate fuel would be exclusively used to fullfill the program.

Assuming that all the program's requirements are met by methanol just as a convenient analytic benchmark, we estimate that about 360,000 barrels per day of methanol would be required in 2004, the last year of the program. This additional methanol might come from as many as 21 new plants of current world scale size or a fewer number of plants if larger advanced technology plants are built.

The total cumulative cost of these plants using our own research is estimated to range between $4.8 and $6.8 billion. The additional cost of fuel flexible vehicles is estimated to be $2.5 billion by the year 2004. Changes to refueling outlets, otherwise known as service stations, to provide fuel for these vehicles would cost approximately $820 million up to 2004.

In terms of energy security, we do think that methanol use would displace oil imports. Assuming the worst case, which is that methanol would come from the Middle East, we think there still may be potential benefits. Even assuming that natural gas continues to be the fuel of choice to generate methanol, natural gas resources are not quite as concentrated in the Middle East as our oil resources. There is certainly more available in the Western Hemisphere.

Finally, as you are aware, Senator, the Department is moving forward aggressively to constitute the Interagency Commission on Alternative Motor Fuels established by the Alternative Motor Fuels Act of 1988.

The Deputy Secretary hopes within the next two to three weeks, to name the private members of the Alternative Motor Fuels Council. We are hopeful and expect fully to use this council and the programs established by that act to provide information in real time experience not only with methanol but with other alternative fuels to feed into the EPA administrator's program in establishing the cleanest possible fuels program under the President's Clean Air Act.

Thank you.

[The prepared statement of Ms. Stuntz follows:]

STATEMENT

OF

LINDA G. STUNTZ

DEPUTY UNDER SECRETARY FOR
POLICY, PLANNING AND ANALYSIS

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

OCTOBER 17, 1989

INTRODUCTION

I am happy to appear before this committee today to discuss the implications of using methanol as a motor fuel. Methanol is one of several alternative motor fuels that have been identified in the Alternative Motor Fuels Act of 1988 that may provide environmental and energy security benefits. It is also one of several candidate clean fuels that might be used to satisfy requirements of the Clean Fuels Program proposed by the President. Other fuels, such as ethanol, compressed natural gas (CNG), and reformulated gasoline are also fuels that might be used to satisfy the requirements of this program.

Methanol has certain attributes that make it a much-discussed candidate fuel. It is a liquid hydrocarbon fuel whose similarity to gasoline allows it to be used with relatively few changes to existing vehicle technology. Both Ford and General Motors have developed fuel-flexible vehicles that can operate on either gasoline or methanol (M85 - a blend of 85% methanol and 15% gasoline). These vehicles, several of which have been provided to the State of California for its alternative fuels demonstration program, have shown that fuel-flexible, methanol vehicles could be put into commercial scale production in the near future, perhaps as early as model year 1993.

The Department of Energy (DOE) has been studying alternatives to petroleum-based fuels for some time because the transportation sector's near total dependence on oil plays a crucial role in U.S. oil import dependence. Oil use by the transportation sector in 1988 exceeded 10 million barrels per day, up more than 2 percent from 1987, and almost 20 percent higher than in 1973. Transportation oil use alone exceeded U.S. production of petroleum in 1988 by 900 thousand barrels per day. Even if we assume substantial energy conservation, fuel switching in industry and buildings, and cars achieving fuel economy above 40 miles per gallon by the year 2000, we estimate that U.S. oil use will remain at about the same level for the next 10 to 12 years. Since domestic oil production will decline almost inexorably, even extraordinary conservation efforts will not prevent increased dependence on imported oil.

Alternative fuels such as methanol, ethanol, CNG, and electricity have the potential to enhance both our technical options and our market options in the frequently volatile world energy markets. Fuel-flexible and dual-fueled vehicles would allow consumers to choose among competing fuels. Other sectors of the economy (electricity generation, for example) have benefitted from this flexibility. But, transportation remains almost entirely dependent on oil.

DOE'S STUDY

In order to evaluate the opportunities that alternative fuels may provide, the Department of Energy has undertaken a comprehensive assessment of the costs and benefits of flexible and alternative fuel use in the U.S. transportation sector. This assessment has focused on:

1) What changes must be made to vehicles and the fuel distribution infrastructure to permit use of alternative fuels,

2) the cost and likely sources of supply of alternative fuels, and

3) any potential safety and environmental problems that alternative fuel use may pose.

DOE already has issued a number of reports as part of this assessment including: Progress Report One: Context and Analytic Framework; Progress Report Two: The International Experience; Technical Report One: Study Objectives and Methodologies; and Technical Report Two: A Context for Estimating Economic and Energy Security Benefits. More reports will be issued in the near future, including: Technical Report Three: Methanol Production and Transportation Costs.

FEEDSTOCKS FOR METHANOL - NEAR TERM AND LONG TERM

Currently, and in the near-term (up to at least the year

2000), it is less expensive to produce methanol from natural gas than from either coal or biomass. However, in the longer term (past the year 2000), coal or biomass may be competitive with natural gas as a feedstock for methanol. DOE has research efforts in both areas in order to best utilize vast U.S. coal and biomass resources.

ECONOMICS OF METHANOL PRODUCTION

The Department has investigated the cost of producing methanol from natural gas and coal using existing and advanced methanol production technologies. The cost of producing methanol depends on a great many factors, including cost of the feedstock, plant size and location, capital recovery rate, and transportation costs. Also, since it takes almost two gallons of methanol to get the same energy as one gallon of gasoline, the fuel equivalency of gasoline and methanol must be taken into account.

For natural gas based methanol, the analysis shows that, depending on the assumed price of natural gas and return to the investor, methanol can be produced (plant-gate cost), using current technologies, at a cost that ranges from under 40 cents per gallon to over 50 cents per gallon. Use of advanced technology plants could reduce future costs to as low as 28 cents per gallon. The cost of production depends, to some extent, on the location of production facilities. Costs will be higher if production facilities are built in remote locations that are near significant supplies of natural gas, but have no supporting infrastructure and are likely to have high labor costs or low productivity. Examples of such locations are Alaska, the Canadian and Norwegian Arctic and the Northwest Shelf of Australia. Therefore, even with low natural gas prices, these extremely remote locations are likely to be more costly sources of methanol than other regions in Central and South America or the Middle East.

In the longer term (past the year 2000), assuming higher natural gas prices world wide, even the most remote locations may become more competitive. In the same vein, methanol produced from domestic coal may also become competitive. We estimate that, with combined production of electricity and methanol, coal-derived methanol can be produced at costs of about 55 cents per gallon. Production of methanol from coal without cogeneration of electricity would cost over 70 cents per gallon.

We have not completed our estimates of the costs of producing methanol from biomass. However, DOE's research is working toward a goal of 55 to 60 cents per gallon in the year 2000 or soon thereafter and believes that biomass will be able to compete with coal derived methanol.

LIKELY SOURCES OF METHANOL

The most likely sources of methanol for the U.S. market remain uncertain. However, it is possible to make some observations about the possible evolution of a fuel methanol market. Until U.S. production capacity can be significantly increased in a competitive manner, it is likely that much of the initial methanol which would supply a U.S. market would be imported. Several major methanol production projects using natural gas are underway in Venezuela. These developments are significant because, aside from the U.S., Venezuela has the largest gas reserves in the hemisphere. In addition, both Argentina and Chile have been active in the methanol market. Trinidad and Tobago are also likely candidates for future projects. While Ecuador does not appear to have current plans or projects, its low-cost gas reserves make it a likely candidate for future development. While Mexico has relatively large reserves, it is less likely to be a factor due to a large potential domestic demand for gas and an apparent determination to expand its gas distribution infrastructure.

Outside of our hemisphere, North Africa and the Middle East are likely suppliers of methanol. In the Middle East, the country with the largest regional natural gas reserves, Iran, is unlikely to be a factor in the market in the foreseeable future. Iran probably lacks the technical wherewithal and capital to undertake such projects on its own and is currently viewed as an unattractive candidate for foreign investment. However, on the other side of the Gulf, several countries could prove important. Saudi Arabia and Qatar both have large reserves of natural gas. Saudi Arabia has an existing petrochemical infrastructure and methanol production capacity. Consequently, additional plants can be built in Saudi Arabia at relatively low costs. Qatar, since it has relatively little oil, has a strong economic motivation to export gas or products made from gas. Methanol facilities may provide an opportunity to do so.

Taken as a whole, the Middle East and North Africa are capable of supplying vast quantities of methanol - significantly greater than can be provided from our hemisphere. However, it will take many years before the demand for such high volumes of methanol can develop. South and Central America alone could provide over a million barrels per day of methanol supply, substantially more methanol than would be required by the President's Clean Fuels Program, even if methanol were the only fuel used. In addition, the Far East (Indonesia, Malaysia, Thailand, Australia and New Zealand) possesses large gas reserves and would be capable of providing methanol in large volumes.

The Department believes that methanol production capacity will not necessarily develop in proportion to the gas reserves held by each potential producer. Areas such as Argentina and Chile, whose reserves are small compared to certain Middle East countries, are already active and can support significantly increased methanol production as the market develops.

In the long run, if methanol demand is measured in terms of several million barrels per day of product, North Africa, the Middle East, and potentially, the Soviet Union could emerge as powerful actors in a gas-derived methanol market. The attached table provides estimates of the proven reserves of countries that have the potential to be low cost suppliers of natural gas for methanol production. Even countries with relatively small reserves can produce large amounts of methanol. This table provides a rough guide as to which countries could be major suppliers in a methanol market that would be so large as to displace high percentages of gasoline use world wide. However, a great deal of time would be required for this to occur, even under the most aggressive methanol-use scenarios (past 2005 to

2010). By this time, increases in world oil and gas prices, coupled with research and development advances, may combine to make coal or biomass derived methanol competitive. Under this scenario, the United States could become a competitive producer able to meet its methanol needs from domestic feedstocks of coal or biomass.

As we have learned, sometimes painfully, over the past two decades, no one can predict future energy prices with precision. Forecasting the future of the world methanol market is no easier. The current 400 thousand barrel per day market is a small fraction of the methanol production which would be required to displace enough oil to have significant implications for U.S. energy security. For example, current methanol production must increase by a factor of 6 to displace 1 million barrels per day of petroleum. Forecasting the nature of such a vastly expanded industry is further complicated by the extreme volatility of methanol prices. Over the last several years we have witnessed swings from 30 cents per gallon up to 70 cents per gallon, and have, just recently, witnessed the market plunge to 20 cents per gallon. Such volatility makes it difficult to estimate the conditions under which investors will commit the very large sums of capital required to expand methanol production capacity sufficiently to displace significant quantities of oil.

CARBON DIOXIDE EMISSIONS OF METHANOL AND NATURAL GAS

The CO_2 emissions caused by the use of methanol, compared to use of gasoline, depend on the feedstock from which methanol is produced. Methanol produced from natural gas provides a slight reduction (less than 5 percent) of CO_2 emissions compared to use of gasoline. However, to the extent that methanol is produced from flared or vented natural gas, the reduction of CO_2 or other greenhouse gas emissions would be more significant.

Using current technology, methanol produced from coal could increase CO_2 emissions by 40 percent relative to use of gasoline. This could be reduced to essentially the same CO_2 emissions as gasoline if the heat required to produce methanol were provided by an energy source that did not generate CO_2 emissions.

Use of methanol produced from biomass could substantially decrease CO_2 emissions, relative to use of gasoline, depending on the exact nature of the biomass feedstock and the conversion technology. The same can be said for biomass-derived ethanol, which can be also be used in methanol-powered vehicles.

We have also estimated that the use of CNG would result in a about a 20 percent reduction of CO_2 and other greenhouse gas emissions compared to the use of gasoline.

These estimates lead us to conclude that the near-term use of natural gas-derived transportation fuels (methanol and CNG) would provide a slight to moderate reduction in greenhouse gas emissions, while biomass derived methanol (or ethanol) could provide substantial reductions in the long term.

THE PRESIDENT'S PROPOSED CLEAN FUELS PROGRAM AND METHANOL

Methanol is one of several candidate clean fuels that might be used to satisfy the requirements of the Clean Fuels Program proposed by the President. Other fuels, such as ethanol, CNG, and reformulated gasoline might also be used to satisfy the requirements of this program.

In response to questions provided by the Committee, we are providing estimates of the costs and volumes of methanol required by this program if the nine affected urban areas used fuel-flexible vehicles operating on M85 to comply with the program. This is merely an analytic assumption with which to provide estimates to the committee and is not a projection of what the President's Clean Fuels Program will be. For instance, it does not take into account the opt-in or opt-out provisions.

In 1995, the first year of the program, 30 thousand barrels per day of methanol would be used, displacing 15 thousand barrels per day of gasoline in the nine cities. By 2000, methanol use would increase to 240 thousand barrels per day. By 2004, methanol use would increase to 362 thousand barrels per day.

In order to satisfy this methanol demand, while still providing methanol for current demand, additional methanol production facilities would be required. Assuming that current technology plants were constructed (20 thousand barrels per day rated capacity), 2 plants would be required by 1995, 14 by 2000, and 21 by 2004. If very large, advanced technology plants were constructed (80 thousand barrels per day), only 4 new plants would be required by 2000, and 6 by 2004. DOE has estimated that the costs of these facilities would be as follows:

Cumulative Capital Cost of New Methanol Facilities
($ millions)

	Current Technology Plants		Advanced Technology Plants	
Year	Cost	No. Req.	Cost	No. Req.
1995	600	2	NA	NA
2000	4500	14	3200	4
2004	6800	21	4800	6

Use of advanced technology plants could significantly reduce required capital costs and could also result in lower methanol costs. If a large fuel methanol market develops, these large-scale plants could eventually come about. However, it is difficult to predict exactly when they would become available. We do not believe that all of the methanol required by the President's program will be provided by such plants. The most likely outcome would be some combination of current technology and advanced technology plants. Consequently, the above table should be regarded as a range, with the actual cost being somewhere in between.

It is possible that all of these plants could be constructed in this hemisphere without excessively depleting South and Central American gas reserves. However, plants could also be built in other parts of the world to help satisfy this demand.

The minimum number of refueling outlets dispersing methanol that would be required is 1,500 by 1995, 12,000 by 2000, and almost 20,000 by 2004. As required under the President's Program, 500,000 light duty vehicles are required by 1995, 750,000 by 1996 and 1 million in 1997 through 2004. Using DOE's estimates of costs for methanol refueling outlets, and the additional costs of fuel flexible vehicles, the following costs would be incurred. These costs do not include any additional infrastructure needed to provide fuel to service outlets such as methanol terminals or tank trucks.

Cumulative Costs of Vehicles and Fuel Distribution Outlets
($ Millions)

Year	Vehicles	Refueling Outlets
1995	140	70
2000	1400	540
2004	2500	820

The accumulated capital investment represents only one quarter of one percent of the national capital investment which will be made in light duty vehicles and fuel distribution outlets over the same time periods.

The Department does not believe that methanol will be the only fuel used to implement the President's proposal. Consequently, it is unlikely that the number of methanol-powered vehicles, refueling outlets, or methanol production facilities will be this great since no single fuel is likely to serve 100 percent of the program.

We would be happy to supply to the Committee with similar estimates of the costs of satisfying 100 percent of the program using CNG vehicles.

CONSUMER COST OF METHANOL

The President's Program calls for alternative fuels to be provided to the consumer at competitive prices. As pointed out above, the methanol market has been very volatile. This makes future price projections very uncertain. It is important to keep in mind, however, that methanol would represent a small percentage of total fuel use in the affected urban areas. Therefore, any cross-subsidization that might be required to keep the consumer cost of methanol competitive with that of gasoline would probably have a relatively minor effect on the price of gasoline. For example, if methanol required a 5 cents per gallon subsidy in 1995, gasoline prices in the affected urban areas would only need to be increased by 0.1 cents per gallon to finance the subsidy. As methanol use increased, this could increase to 0.8 cents per gallon (2000) and 1.2 cents per gallon (2004).

ENERGY SECURITY IMPLICATIONS OF METHANOL USE

Methanol use would displace oil imports. Although the methanol itself would be imported, natural gas reserves are more evenly distributed around the world than are oil reserves. As discussed above, substantial methanol production could come from countries in this hemisphere. The ability of this hemisphere to supply increased demand for oil is much more limited.

In the worst-case situation, incremental methanol supply would be provided from the Middle East. This may provide little advantage relative to increased oil supply from the same region. However, even in this situation, there are certain potential benefits. Methanol production is capital intensive. If methanol production is stopped or slowed, principal and interest on the financed part of the plant will continue. Therefore suppliers of methanol have more economic incentive to keep methanol production at full capacity. Of course, not all interruptions of supply are caused by decisions of supplier countries. War, terrorism, or other physical interruptions can also disrupt supply. Methanol plants would be at least equally vulnerable to such activity.

In the long run (past 2000), methanol use may provide an opportunity to significantly enhance U.S. energy security. With large domestic coal and biomass resources, we have the potential to supply domestic methanol demand using these indigenous feedstocks. We may also be able to produce cellulosic ethanol in large quantities. These opportunities will depend on the future economics of methanol and ethanol production. DOE is actively supporting research to make these domestic options economically competitive in the future.

The potential energy security benefits of methanol use are increased when methanol is used in fuel-flexible vehicles, as opposed to dedicated vehicles. If methanol supplies are interrupted, users of methanol in fuel-flexible vehicles can switch to gasoline. This need not be an overriding factor when assessing the relative benefits of dedicated or fuel-flexible vehicles, especially if the number of vehicles is relatively small. However, when evaluating the implications of introducing large numbers of methanol vehicles, it is one factor that should be considered.

The Department is leading a comprehensive interagency assessment of the energy security and other implications of all alternative fuels. This assessment is being conducted in the context of the Interagency Commission on Alternative Motor Fuels which is chaired by the Deputy Secretary of Energy. The conclusions reached by this Commission and its advisory body, the U.S. Alternative Fuels Council, will be provided in annual interim reports in 1990, 1991 and a final report by September 30, 1992 to help us chart the best national policies on alternative fuels and to assist the EPA Administrator on implementing the President's Clean Fuels Program.

This concludes my prepared remarks. I would be happy to answer any questions that the committee may have.

Table 1

Areas with Prospectively Low-Cost Natural Gas Reserves
(Proven Reserves - TCF)
(Year End - 1988)

OECD	
Alaska	9
Canadian Arctic	56
Norwegian Arctic	19
Australia	17
New Zealand	5
PERSIAN GULF OPEC	
Iran	494
Saudi Arabia	152
Kuwait	49
U.A.E.	202
Qatar	157
OTHER OPEC	
Indonesia	84
Algeria	104
Libya	26
Nigeria	85
Venezuela	102
Ecuador	4
NON-OPEC, NON-OECD	
China	32
Thailand	4
Malaysia	52
Mexico	75
Trinidad, Tobago	10
Argentina	27
Chile	4
Soviet Union	1500
WORLD RESERVES	3936

Sources:

U.S. Department of Energy, Energy Information Administration, International Oil and Gas Exploration and Development Activities, Quarterly Report, First Quarter 1989.*

U.S. Department of Energy, Energy Information Administration, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves: 1988 Annual Report, September 1989.*

Senator **Rockefeller**. Thank you.

Dr. Friedman.

STATEMENT OF DR. ROBERT M. FRIEDMAN, SENIOR ASSOCIATE, OCEANS AND ENVIRONMENT PROGRAM, OFFICE OF TECHNOLOGY ASSESSMENT, ACCOMPANIED BY STEVEN E. PLOTKIN, SENIOR ASSOCIATE, ENERGY AND MATERIALS PROGRAM

Dr. **Friedman**. Thank you, Mr. Chairman.

I am accompanied by my colleague, Steven Plotkin.

Let me start by saying that while we would all like an alternative fuels program that achieves the highest possible improvement in air quality as quickly as possible and at the lowest possible costs, tradeoffs among these goals are inevitable. Congress toughest task, I believe, is deciding which of these goals is most important. A program that achieves modest reductions in the 1990s may not be the best be for achieving deeper cuts a decade later.

Moreover, since money and technical resources are not unlimited, how much energy should be devoted to alternative fuels versus other pollution control opportunities—and there are others. We disagree with EPA on that point—alternative fuels are certainly a promising control measure but one that may turn out to be quite expensive or not as effective as hoped.

We feel that the current clean air bills cover the spectrum of the type of alternative fuel programs that Congress can choose from. The two most prominent are the transition approach and the demonstration approach.

I would call the administration bill a transition approach. It starts with a current generation clean fuel technology with expected emissions benefits of about a 30 percent reduction per vehicle and tries to move to an 80 percent reduction technology.

If the program were to be fully implemented with today's technology, it would yield benefits equivalent to reductions of about 1 to 1.5 percent of total VOC emissions in the cities in which it was implemented.

If the transition to tomorrow's technology can be made, reductions could eventually rise to about 3 percent.

The demonstration approach, the other approach, is exemplified by, in particular a House bill H.R. 99. The idea is to apply the program first to a small number of vehicles—for example, centrally fueled fleets—and encourage diversity of approaches and research.

Let me just briefly compare the two approaches. Both seem to have similar goals: cost effective, ultraclean fuel vehicles. Both will be expensive in the near term.

The transition approach attempts to spur demonstration of tomorrow's technology, as Mr. Rosenberg said, by sending signals to the market. The demonstration approach pauses first, puts money into demonstration programs before committing to the eventual path.

The transition approach does provide greater reductions in the near term. The demonstration approach offers greater opportunities for experimentation.

Let me say that our cost estimates for a shift to methanol are quite a bit different than EPA's. We project the retail cost of methanol to be in the range of about $1.15 to $1.50 per gallon gasoline equivalent. This puts methanol fuels at the bottom of our list of currently available ozone control measures from the standpoint of cost effectiveness.

We would be happy to discuss the differences between our analyses. One of the major differences is that EPA is talking about the long-term equilibrium cost. We are focusing mostly on the transition cost, what can we expect to pay in the near term.

You have heard that the energy security implications of methanol use in transportation are somewhat controversial. Methanol will almost certainly be imported because the Middle East and Eastern Bloc have three-quarters of the world's reserves of natural gas. Despite this, we believe that methanol use can be beneficial to U.S. energy security under certain conditions.

First, it must be large enough to have a significant impact because the key benefit is a reduction in U.S. exposure to the economic damages of an oil disruption and price shock. A small program probably will not work and might even lose some energy security.

Second, the number of undeveloped gas fields in the world opens the possibility of the U.S. deliberately targeting methanol supply investments to the most secure area. Even if we leave supply to the free market, we believe that the existence of a large number of areas that could become methanol producers will make a methanol market more competitive than the oil market.

Note, however, that for maximum environmental benefits, methanol promoters hope to move quickly to a dedicated fleet. From the standpoint of energy security, fuel flexible vehicles are probably preferred.

I think I have taken my three minutes. I thank you, Mr. Chairman. We certainly would be happy to answer questions.

[The prepared statement of Messrs. Friedman and Plotkin follows:]

TESTIMONY OF
ROBERT FRIEDMAN AND STEVEN PLOTKIN

OFFICE OF TECHNOLOGY ASSESSMENT

BEFORE THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE
OCTOBER 17, 1989

METHANOL AS A TRANSPORTATION FUEL

Mr. Chairman and Members of the Committee, I am Robert Friedman, a Senior Associate with the Oceans and Environment Program at the Office of Technology Assessment. I am accompanied today by Steven Plotkin, who is a Senior Associate in OTA's Energy and Materials Program. We appreciate this opportunity to report to you on OTA's work on the role that methanol fuels can play in increasing U.S. energy security and reducing urban ozone and other pollutants in our Nation's urban areas.

In OTA's recent report, Catching Our Breath: Next Steps for Reducing Urban Ozone[1], we examined the role that methanol and natural gas could play in reducing air pollution levels in U.S. cities remaining in violation of air quality standards for ozone. In a follow-on to this work, we have been examining issues involved in implementing an alternative fuels strategy.

Also, as part of its Energy Outlook Study, OTA has been investigating the costs and benefits, including energy security implications, of the use of a wide range of fuels -- methanol, natural gas, ethanol, hydrogen, electricity, and reformulated gasoline -- in light duty vehicles. This latter study is well advanced, and an early draft report was reviewed a number of months ago. A final draft report will shortly enter the review process.

Our testimony today will rely primarily on Catching Our Breath and our follow-on work, with some general information from other OTA analyses. Mr. Plotkin and I will both be available to answer questions following our statement.

Our testimony will cover three major topics. First, we will outline the factors Congress must consider when designing an alternative fuels program to improve urban air quality. Though the ideal is to design a program that achieves: 1) the highest possible improvements in air quality, 2) as quickly as possible, 3) at the lowest possible cost, tradeoffs exist among these goals. The costs of any alternative fuels program will be expensive in the near-term. Thus, Congress should consider each of the options as an "investment" in future air quality control, choosing among several highway vehicle options as well as some promising stationary source control measures.

We will then cover OTA's view of the costs and cost-effectiveness (the cost per ton of pollutant removed) of methanol. Our remarks will focus on the costs one can expect over the next decade or two, that is, the "transition" to a multifuel transportation system.

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[1] Office of Technology Assessment, Catching Our Breath: Next Steps for Reducing Urban Ozone, OTA-O-412, July 1989.

We also review uncertainties that remain about the air quality benefits that will be achieved from methanol vehicles in use. Finally, we will discuss the energy security benefits to be gained by lowering gasoline use through the use of methanol fuels.

AIR QUALITY GOALS

The ozone nonattainment problem:

About 100 cities, housing about half of the American population, do not meet the standard for ozone, the principal component of urban smog. A key finding of our report, Catching Our Breath, is that currently available technology can bring into compliance only about half of these areas. Existing control methods can substantially improve the air quality in the other half of the areas, but meeting the ozone standard in these areas will require new, innovative, and nontraditional control methods.

The difficulty and timeframe for meeting the ozone standard varies from city to city. Some cities can expect to meet it within about 5 years using existing controls; others might be able to meet it in about a decade *if* new technologies are soon found. But many cities will still not meet the standard before 2000 and several major cities will need 20 or more years to develop and implement new control methods.

We concluded that Congress will have to set programs into motion now if new and cost-effective control methods are to be available by the year 2000. We cautioned, however, that no single new control method will work in all areas, thus Congress would be wise to pursue several approaches simultaneously. We discuss five promising candidates, of which alternative fuels is one. Alternative fuels are being considered because the volatile organic compounds (VOCs) they emit have a lower potential to form ozone than the VOC emissions from gasoline vehicles.

In Catching Our Breath, we estimated that about 25 to 30 percent of VOC emissions remaining after today's controls are applied will come from cars and trucks. In a subsequent analysis[2], incorporating some control measures for gasoline vehicles that we had not previously considered, we estimated that highway vehicle emissions might be controlled further to about 15 percent of total VOC emissions.

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[2] "An Analysis of Selected Mobile Source Provisions in H.R. 3030 and H.R. 2323", Staff Paper prepared by the Oceans and Environment Program, Office of Technology Assessment, September 21, 1989.

Use of alternatively fueled vehicles, for example using methanol or compressed natural gas (CNG) instead of gasoline, can lower emissions further. Reducing the Nation's use of cars through the use of transportation control measures (TCMs) is another alternative for further lowering highway vehicle emissions.

About a quarter of the remaining VOC emissions will come from solvents used in a wide variety of industrial, commercial, and home uses, from painting and cleaning heavy equipment to washing paintbrushes. This is a tempting, but particularly difficult-to-control category.

For some areas, controlling NOx emissions in addition to VOCs may be part of the answer, both locally and in areas upwind of certain nonattainment cities. However, *under some conditions at some locations*, reducing NO_x can *increase* ozone concentrations above what they would be if VOCs were controlled alone.

Finally, whatever regulatory approaches for reducing urban ozone concentrations are chosen, a modest investment in research today will pay off in better decisions and continued progress 10 years from now. EPA's annual budget for new and cheaper control methods has been less than one-tenth of one percent of the projected cost of control. Continued underfunding may doom the program to failure once again.

Defining goals for an alternative fuels program:

Everybody would like an alternative fuels program that achieves: 1) the highest possible improvements in air quality, 2) as quickly as possible, 3) at the lowest possible cost. But which of these is most important? If one has to choose between a program that achieves modest emissions reductions in the 1990s and a program that might achieve deeper cuts a decade later, which is preferred? Or a choice between timing and cost?

Moreover, since monetary and technical resources are not unlimited, how much regulatory energy should be devoted to an alternative fuels program and how much to other pollution control opportunities? The transition to alternative fuels will be expensive. As mentioned above, alternative fuels are one of several new control measures Congress should be considering -- a rather promising one, at that -- but one that might turn out to remain quite expensive or not as effective in improving air quality as desired. These are the issues that Congress must face when specifying an alternative fuels program.

Most of the current ozone nonattainment bills (for example, S. 1490, H.R. 2323, and H.R. 3030) specify the timing for adoption of an alternative fuels program. Most also specify *part* of the equation that determines the eventual air quality benefits -- the number of vehicles affected -- but do not specify how much "cleaner" than gasoline an alternative fuel must be to qualify. This decision is typically left to the Administrator of EPA, the States, or both, thus making it difficult to determine the air quality benefits. We would assert that this is a _policy_ question, not a technical one, and thus would be better specified by Congress.

The _costs_ of the program, of course, are not specified, but the design of the program can have a significant effect on cost. One way to lower costs is to mandate a full-scale program that affects enough vehicles and uses enough fuel to capture economies of scale. Another approach takes the opposite tack: proceed with smaller demonstration programs to stimulate technological advances that might lower costs. Other elements of program design are important as well, for example, whether there is enough certainty in the program to attract investors.

The air quality benefits from an alternative fuel program can vary widely. At the low end, use of "M85", a mixture of 85 percent methanol and 15 percent gasoline, in centrally owned fleets alone will yield benefits equivalent to about a 0.7 percent reduction in total VOC emissions. Use of a "cleaner" alternative fuel, for example, compressed natural gas (CNG), in _all_ passenger cars and light trucks might yield benefits equivalent to about a 10 percent reduction in total VOC emissions.

In the examples above, there are two factors that determine the outcome. The first, of course, is the _reductions per vehicle_, that is, how "clean" is the clean fuel. Some fuel/vehicle combinations achieve _moderate_ reduction levels. For example, M85 used in flexibly fueled vehicles (that is, vehicles that can use either M85 or gasoline) might achieve per-vehicle benefits equivalent to about a 30 percent reduction in VOC emissions as compared to a similar gasoline vehicle. Reformulated gasoline might be able to achieve a similar level of improvement. Other vehicle/fuel combinations might be able to achieve very _high_ levels of reductions, approaching per-vehicle benefits equivalent to an 80 to 90 percent reduction in VOC emissions. These include vehicles that _exclusively_ use M100 (100 percent methanol) or CNG. As mentioned above, most of the major ozone nonattainment bills leave a tremendous amount of discretion about the choice of alternative fuel (and thus the reductions achieved) to the Administrator of EPA, the States, and the auto manufacturers.

At the risk of adding more jargon to an already confusing debate, we will define two terms. To refer to those technology/fuel combinations with a potential for moderate reductions, we will use the term "clean fuel" vehicles. To refer to those technology/fuel combinations with a potential for high reductions (80 percent or more), we will use the term "ultra-clean fuel" vehicles.

Obviously, if all things were equal, one would prefer an "ultra-clean fuel" vehicle to a "clean fuel" one. But all things are not equal. Clean fuel vehicles are on the road today and programs could begin in the 1990s. Practical ultra-clean fuel vehicles do not yet exist and several technical, institutional, and most important, economic barriers remain to their acceptance. For example, vehicle developers have not solved the problem of cold-starting engines using M100.

Nevertheless, the eventual goal in most cases will be to adopt ultra-clean fuel vehicles. Not only is the potential for emissions reduction greater, but so is the chance of the reductions being cost effective. For example, the total costs to consumers to operate an M100 vehicle may be about the same -- or even lower -- than an M85 vehicle, but an ultra-clean dedicated M100 vehicle may yield two to three times the reduction benefits of a flexibly fueled M85 vehicle.

During the early stages of a program, methanol is likely to be significantly more expensive than gasoline on a cost/mile basis. Consequently, methanol can succeed as an alternative to gasoline only if it obtains a strong subsidy or regulatory requirements. With time, however, methanol costs will drop, but whether costs will drop enough so that the air quality benefits are considered cost effective is an open question. A later section of this testimony will discuss the cost question in greater detail.

A second decision that Congress must make is the percentage of vehicles affected by the alternative fuel program. One bill, H.R. 99 limits the program to centrally owned fleets in the worst nonattainment areas, about 5 to 10 percent of light duty vehicles in these cities. The bill also requires federal fleets in all nonattainment areas to use alternative fuel vehicles. Both S. 1490 and H.R. 2323 specify that about 30 percent of vehicles in the worst cities must be alternative fuel vehicles. In addition, H.R. 2323 requires that in extreme nonattainment cities, i.e. the Los Angeles Basin, 100 percent of new highway vehicles must be alternative fuel vehicles. S. 1630 has no Federal requirements for use of alternative fuel vehicles *per se*, but does establish emission standards for gasoline light duty vehicles by the year 2003 that may only possible to meet with reformulated gasoline.

Again, if all things were equal, one would prefer a "medium" or "high" percentage program to a lesser one. But again, all things are not equal: If the purpose of the program is to develop and demonstrate a wide range of ultra-clean fuel technologies -- dedicated M100 or CNG vehicles, electric vehicles, etc. -- then one would prefer a smaller, targeted program. The only larger scale programs plausible today are based on clean fuel technology -- most likely flexibly fueled M85 and possibly reformulated gasoline or dual-fueled CNG. A medium size program, for example a 30 percent mandate for flexibly fueled M85, may help you develop a market and infrastructure for methanol fuel that will allow you to move to the more effective dedicated M100 program, but again it may not. Fuel costs may remain high or the remaining technical problems may remain unsolved. In a decade from now we may have spent large sums of money on a transition program and find ourselves no closer to a cost effective, ultra-clean fuel program.

Options for Clean Fuel programs:

The current bills seem to cover the spectrum of the type of alternative fuel programs Congress can choose from. These seem to fall into three categories:

1) The Transition Approach. Congress could specify a program that applied to a significant fraction of passengers cars and light trucks, beginning in the 1990s, knowing that all that can be counted on in the near term is clean fuel technology. Both S. 1490 and H.R. 2323 follow this approach for the worst nonattainment areas, requiring about 30 percent of new vehicles to use clean fuels. If the program were to be fully implemented with clean fuel technology, it would yield benefits equivalent to reductions of about 1 to 1.5 percent of total VOC emissions in those cities.

But the goal of starting with a fairly large percentage of vehicles is to encourage the transition to either ultra-clean fuel technology, or to lower the costs of operating clean fuel vehicles so that a larger fraction will be used, or both. If the transition to ultra-clean fuel technologies is successful, reductions could eventually rise to about 3 percent. If the transition is not successful, but clean fuel vehicles turn out to be cost-effective, reductions could also be increased to about 3 percent or even higher by raising the percentage of affected vehicles. This approach assumes that within the next few years, it is possible to map out a strategy that will apply for the following decade. Given the timing of S. 1490 and H.R. 2323, methanol is probably the only candidate fuel that used in clean fuel vehicles in the mid-1990s (as M85) and that might make the transition to ultra-clean fuel vehicles past 2000 (as M100). The risk of mapping out a strategy in the next few years, of course, is that some of your assumptions turn out to be incorrect -- for example, the cost of methanol remains high -- and the program ends because it is not judged to be cost effective.

2) The All Out Approach. A variation of the "transition" approach is included in H.R. 2323 for the most severe nonattainment areas, (the Los Angeles Basin). All new passenger cars and light duty trucks are required to be alternative fuel vehicles by the year 2000, but clean fuel vehicles such as M85 are acceptable, unless the Administrator disallows them. Assuming these remain acceptable, the program should yield benefits equivalent to reductions of about 4 to 5 percent of total VOC emissions by 2010 in the cities in which it is implemented. If a successful transition to ultra-clean fuel technology takes place, this could rise to 10 percent. The emphasis in this type of program is on obtaining whatever near-term reductions are possible as soon as possible.

3) The Demonstration Approach. Congress could specify a program that applies to a small number of vehicles (for example, centrally fueled fleets) and encourages a diversity of approaches. H.R. 99 is probably closest to this approach. The goal is to develop ultra-clean vehicles, either dedicated M100, CNG, and electric vehicles. As will be discussed below, costs of the larger scale "transition approach" above will be considerable in the near term. Money may be better spent focused on developing and demonstrating ultra-clean vehicles (or even methods to control emissions from stationary sources), rather than encouraging development of an infrastructure to support an early choice of alternative fuel. Reductions will be modest in the near term, but might lead to later reductions equivalent to a successful transition to ultra-clean fuel vehicles. Missing from H.R. 99, however, is a method to channel R&D support to the centrally fueled fleets that are affected.

Let me compare the "transition" approach to the "demonstration" approach. Both seem to have similar goals: cost-effective, ultra-clean fuel vehicles. Both will be expensive in the interim. The former approach hopes to reap some economy-of-scale benefits by mandating a fairly high percentage of vehicles, but total costs will be high because the number of vehicles is high. The demonstration approach will probably be less cost effective in the near term, that is, higher costs per vehicle and higher costs per ton of VOC removed. But the smaller number of vehicles will hold the total program costs down, well below the first approach, if desired.

The transition approach attempts to spur demonstration of ultra-clean technology, hold the costs down, and get supporting infrastructure in place by sending signals to the market of a commitment to a large program. The demonstration approach pauses first, puts money into demonstration programs, before committing to an eventual path.

We do not know which approach is more likely to reach the eventual goal of cost-effective, ultra-clean fueled vehicles. Once 30 percent of a city's vehicles are fueled by M85 or reformulated gasoline, there may be little incentive for a further technology push. If one will be satisfied with clean fuel vehicles rather than ultra-clean vehicles, recognizing that cost effectiveness could be high and emissions reductions modest, then the transition approach may be preferable. However, if such an outcome is not satisfactory, then the demonstration approach might be preferred.

COST-EFFECTIVENESS OF A METHANOL FUELS PROGRAM

Reliable estimates of the cost-effectiveness of methanol in reducing urban ozone depend in turn on reliable estimates for both the likely costs of the fuels and vehicles and the likely improvements in air quality that the program will create. We believe that there remain important uncertainties associated with both cost and air quality impact estimates. These uncertainties are generated by both technical uncertainties (for example, inadequate understanding of physical relationships, and uncertainty about the future success of critical technologies) and uncertainties about future decisions (for example, required rates of return for investors, manufacturer design decisions, regulatory decisions, and consumer preferences).

In Catching Our Breath, OTA concluded that a shift to methanol was a relatively expensive way to control urban ozone. We projected the cost of methanol landed at U.S. ports to be about 40 to 60 cents/gallon wholesale, and $1.15-$1.51/gasoline gallon equivalent at retail (taxes included). Based on this range of values, we calculated the cost-effectiveness (in $/ton of reduced reactive hydrocarbon emissions) of the use of M85 in flexibly-fueled vehicles in the general fleet to be $8,700-$66,000/ton; similarly, we estimated the cost-effectiveness of the use of straight methanol in dedicated vehicles in the general fleet to be $3,200 - $22,000/ton.[3] In these calculations, we accepted EPA's estimates of the emissions reductions obtainable with these fuels as a baseline assumption. We are now continuing our analysis of both the likely emissions reductions and the costs associated with the use of alternative fuels.

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[3] **Assumptions:** for M85 with conventional engine technology, 30 percent reduction in effective emissions of volatile organic compounds (VOC); with M100 and optimized, dedicated vehicles, 90 percent reduction in effective VOC emissions as an upper bound (EPA assumes that a most-likely value for the reduction will be 80 percent). Added cost of the dedicated M100 vehicles, $0-$1000/vehicle depending on the size of the production run. Gasoline retail cost, $.95 and $1.10/gallon for regular and premium unleaded, respectively, with average costs at $1.025/gallon assuming methanol substitutes for premium in half of the methanol vehicles.

With the assumed emissions reductions and estimated costs discussed above, methanol ranked at the bottom in cost-effectiveness in the group of emission reduction strategies OTA examined. Furthermore, in calculating methanol's benefits, OTA assumed that highway vehicle and fuel standards would remain unchanged except for limits on gasoline volatility being lowered to 9.0; because standards *are* likely to change in ways that will reduce vehicle emissions, this assumption tends to exaggerate the relative benefits obtainable from a shift to methanol.

Uncertainty in cost estimates:

The Committee should be aware that the Environmental Protection Agency has come to very different conclusions than OTA about the cost-effectiveness of a shift to methanol in transportation markets. EPA has concluded that a shift to methanol would be an extremely cost-effective measure to control urban ozone. EPA has projected the cost of methanol to be about 35 cents/gallon wholesale, $1.05-$1.09/gasoline gallon equivalent at retail for flexibly-fueled vehicles, and $.85-$.88/gasoline gallon equivalent at retail for optimized, dedicated vehicles using M100. Based on these costs (but using a higher baseline gasoline price than OTA's -- $1.08/gallon for regular unleaded, $1.23/gallon for unleaded premium,[4] and $1.12/gallon for a sales weighted average price,[5] versus OTA's $1.025/gallon), EPA projects methanol to eventually be less expensive than gasoline.

We have discussed the differences between the OTA and EPA analyses with EPA personnel, and we have exchanged memoranda discussing our mutual concerns. Based on these exchanges, we can explain the remaining differences between EPA's and OTA's positions on methanol costs as follows:

First, simply adopting the same gasoline baseline price reduces somewhat the differences between the OTA and EPA estimates. Using EPA's assumed $1.12/gallon in our analysis, the cost-effectiveness of dedicated vehicles in the general fleet improves from $3,200 - $22,000/ton to $800 - $20,000/ton.

Second, EPA and OTA are looking at quite different scenarios. EPA's cost analysis attempts to estimate the long-term "equilibrium" costs of methanol, after a large, stable market for methanol has become established, while OTA's analysis focuses on a more limited program that does not attain the scale advantages and requires more expensive risk capital. Many of the costs presented by EPA in its analysis would go up *substantially* at the likely scale for shorter-term supply. For example, a single 10,000 ton-per-day (TPD), four train facility – EPA's baseline plant – would supply over a billion gallons per year of methanol. One plant this size represents over 10 percent of current world methanol production capacity, and would be capable of fueling over 2 million vehicles. It is questionable whether investors would agree to build plants this large for an untested market. If smaller plants are built, however, costs will be higher.

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[4] Because methanol has a very high octane level, it may be compared to high octane gasolines.

[5] Office of Mobile Sources, U.S. Environmental Protection Agency, Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel, September 1989.

Third, OTA and EPA disagree about the likely fuel efficiency of methanol vehicles. EPA concludes that dedicated, optimized methanol vehicles will achieve a 30 percent improvement over equivalent gasoline-fueled vehicles. OTA expects that a more likely efficiency increase for such vehicles *in mass production, designed for maximum consumer acceptance*, is 10 percent, or 15 percent if fuel economy becomes a more important market factor than it is at present. In calculating the conversion factor between gasoline and methanol volumes, OTA uses 1.8 rather than EPA's 1.54. Had EPA used a 1.8 conversion factor, its estimated methanol costs for dedicated vehicles would have been higher by about $.15/gasoline-gallon equivalent.

Fourth, EPA uses a 16.2 percent capital recovery factor, based on a 10 percent after-tax rate of return, in its calculation of capital charges for methanol production. EPA's logic is that historic rates of return in the petroleum refining industry have been about 5 percent, and the additional 5 percent covers the *initially* greater risk for a methanol plant and the possibility that the years covered in EPA's referenced analysis may have been somewhat atypical.[6]

OTA is concerned that EPA has addressed only the question of what the return might be after the needed facilities are built; it has not addressed the issue of whether or not investors will be willing to build the methanol plants in the first place. This "build/not build" decision will *not* be predicated on historic rates of return, it will instead be decided on required hurdle rates for large investment decisions. These rates run to 20 percent and higher for projects of this sort, especially in remote locations. Thus, from the viewpoint of the potential investor, the required capital charge component of methanol prices could be twice as high as EPA estimates. This could add as much as $.25-$.30/gasoline-gallon equivalent to methanol costs.[7]

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[6] Office of Mobile Sources, op cit.

[7] Assuming a 1.8 conversion factor from methanol to gasoline.

Fifth, EPA and OTA disagree about the likely size of retail markups for methanol. EPA's analysis includes a presumed lower "per mile" tax burden and lower "per gallon" station markup on methanol than on gasoline. In the absence of experience, OTA believes it would be more prudent to assume that gasoline and methanol station markups will be similar on a volumetric basis, e.g., closer to 9 cents per gallon rather than EPA's assumed 5-7 cents for the service station portion of the markup, and taxes somewhat higher than the assumed 12 cents per gallon to equalize taxes on a "per vehicle mile" basis. Although State and Federal governments may want to stimulate methanol use by applying lower taxes, these lower taxes should be treated as a subsidy, not a free market advantage of methanol over gasoline. With higher retail markups and slightly higher tax rates, methanol prices could be as much as $.09/gasoline-gallon equivalent higher.[8]

To summarize the methanol cost situation, the ability of methanol to compete economically with gasoline depends on several factors that will change through time. In the short term, high risks, inability to achieve scale economies, and the need to start out with proven, and non-optimal, technology is likely to make methanol a rather expensive fuel compared to gasoline. In the longer term, fuel and other costs can come down and fuel use efficiencies rise to lessen the economic gap between methanol and gasoline. However, there remain significant uncertainties and disagreements about just how expensive methanol will be in the long term. In their best case, with optimized, dedicated M100 vehicles, EPA believes that methanol can be significantly less expensive than gasoline even if oil prices remain stable. OTA and others are skeptical of these estimates, and believe that methanol will likely remain more expensive than gasoline -- though perhaps not markedly so -- even after an expensive transition period is passed.

Air quality benefits:

Since cost effectiveness is measured as (cost) divided by (air quality benefit), the estimates of improvements in emissions and air quality are of equal importance to the estimated costs of a methanol fuels program. Methanol has been presented as superior to gasoline in its air quality characteristics primarily because of its low photochemical reactivity. The low reactivity means that organic emissions from methanol vehicles, thought to be largely unburned methanol, should have less ozone-forming potential than an equal weight of organic emissions from gasoline-fueled vehicles.[9]

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[8] Assuming a 1.8 conversion factor from methanol to gasoline.

[9] Alson, J.A., J.M. Adler, and T.M. Baines, "Motor Vehicle Emission Characteristics and Air Quality Impacts of Methanol and Compressed Natural Gas," U.S.E.P.A. Office of Mobile Sources, January 1989.

Limited emissions data and limited experience with methanol vehicles preclude firm projections about methanol's ozone reduction potential. However, typical reductions in ozone-forming potential (as compared to current gasoline-fueled vehicles using low-volatility gasoline) for vehicles operating with M85 and current engine technology are estimated at about 30 percent. With advanced vehicles using M100, reductions of 80 to 90 percent have been claimed.[10] OTA used these estimates in Catching Our Breath.

Skeptics of such expectations for methanol's ability to reduce urban ozone point particularly to the exhaust emissions data for existing M85 vehicles. They are not impressed by the emissions test data for M85 test vehicles when compared to 50,000 mile emission certification test results for today's gasoline vehicles.[11] First, many of the M85 vehicles have shown exhaust hydrocarbon emissions[12] greater than gasoline vehicles, thus offsetting the benefits from the lowered reactivity of M85's exhaust gas. Second, emissions of formaldehyde, which is one of the most photochemically reactive components of auto exhaust, has been higher than hoped for and considerably higher than emissions from gasoline engines. Third, although most analysts believe that emissions of hydrocarbons and other potential ozone-causing pollutants from M85 vehicles will be contribute less to ozone formation than an equal weight of such emissions from gasoline-powered vehicles, some skeptics have questioned this assumption as well, especially during multi-day pollution episodes. Finally, a number of gasoline-fueled vehicles have achieved NOx levels significantly below levels achieved by all of the methanol test vehicles in early emissions tests.

Under examination, the claims and counterclaims are difficult to weigh. Some of the complications include: 1) difficulty in extrapolating the performance of methanol prototypes, using minor adaptations of current technology and M85, to the expected performance of a commercial fleet using new technology and either M85 or M100; 2) substantial difficulties in obtaining accurate measurements of organic emissions from methanol vehicles;[13] 3) mixed evidence about the magnitude of reactive non-methane hydrocarbons (as opposed to relatively unreactive unburned methanol) in exhaust emissions from methanol engines; and 4) greater volumes of highly reactive formaldehyde than would be emitted by comparable gasoline engines, combined with uncertain prospects for catalytically controlling formaldehyde emissions over the lifetime of vehicles. The benefits of M85 could be either greater or less than the 30 percent benefit assumed by OTA. ,

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[10] Alson, J.A., "The Emission Characteristics of Methanol and Compressed Natural Gas in Light Vehicles," paper 88-99.3, presented at the 81st Annual Meeting of the Air Pollution Control Association, Dallas, TX, June 19-24, 1988; U.S. Environmental Protection Agency, Guidance on Estimating Motor Vehicle Emission Reductions from the Use of Alternative Fuels and Fuel Blends, EPA-AA-TSS-PA-87-4, Research Triangle Park, NC, January 1988; and Office of Technology Assessment, Catching Our Breath: Next Steps for Reducing Urban Ozone, OTA-O-412, July 1989.

[11] . Sierra Research, Inc., Potential Emissions and Air Quality Effects of Alternative Fuels - Final Report, SR89-03-04, March 28, 1989.

[12] Methanol vehicle hydrocarbon emissions calculated as Organic Material Hydrocarbon Equivalent, as recommended by EPA, by subtracting the oxygen content of the organic emissions.

The air quality benefits from M100 vehicles will certainly exceed those from M85 vehicles. But because we have no on-the-road experience with M100, it is impossible to say how close we can come in practice to the upper bound estimates of benefits of 80 to 90 percent as compared to gasoline vehicles.

Whatever may be the potential of optimized vehicles burning M100 exclusively, during a transition to methanol, manufacturers will first market flexible fuel vehicles using a methanol-gasoline mixture such as M85. Although flexible fuel vehicles allay some worries about fuel supply and vehicle resale value,[14] they offer less potential than dedicated vehicles for significant improvements in efficiency and emissions relative to gasoline vehicles. Also, flexible fuel vehicles allow the possibility that vehicle owners will shift back and forth from methanol to gasoline depending on price and availability, mixing the two fuels in their tanks and diluting or negating potential air quality benefits associated with methanol use. Even the use of M85 in *dedicated* vehicles will not come close to M100's ozone-reduction potential because M85 has greater evaporative emissions than M100 and will have a higher proportion of reactive hydrocarbons in both evaporative and exhaust emissions.

Conventional air pollutants are not the only emissions that should enter into the methanol decision equation. Because coal could eventually become the raw materials source for a U.S. methanol-fueled highway fleet, there are legitimate concerns about methanol use's eventual impact on emissions of greenhouse gases. Methanol produced from natural gas will produce greenhouse emissions similar to those produced by the gasoline-based fleet, on a system basis.[15] However, methanol from coal will produce substantially higher emissions of greenhouse gases than the current gasoline-based system, primarily because coal has a high carbon content and because the methanol-from-coal production process is inefficient.

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[13] . Beyaert, B., et al, "An Overview of Methanol Fuel Environmental, Health and Safety Issues," Symposium on Alternative Transportation Fuels for the 1990's and Beyond, American Institute of Chemical Engineers, August 22, 1989, Philadelphia, PA.

[14] That is, they can be used, and thus sold, in areas where an extensive fuel supply network has not been constructed yet.

ENERGY SECURITY IMPLICATIONS OF A METHANOL FUELS PROGRAM

With relatively generous worldwide reserves of crude oil available, current interest in gasoline substitutes is based not on the threat of actual physical scarcity of oil but on the potential for supply disruptions and large and sudden increases in price. This concern is heightened by the concentration of oil reserves in the volatile Middle East and the expectations of many analysts that OPEC will regain its former large market power in the 1990s. Development of alternative fueled systems -- vehicles, supply sources, and distribution networks -- is viewed as both a means to reduce dependence on oil, lowering the economic impact of a disruption and/or price rise, and as leverage against oil suppliers -- "raise the price too high, or disrupt supply, and we will rapidly expand our use of competing fuels."

Analysts have argued both for and against the proposition that a U.S. turn to methanol would provide an important strategic advantage. OTA concludes that, under some circumstances, the addition of methanol to the U.S. transportation fuel inventory could improve U.S. energy security for at least a few decades, even though most or all of the methanol would be imported. (The major security benefit would be to reduce U.S. exposure to economic damages from a future oil supply disruption and/or price shock.) Longer term prospects depend on the scale of worldwide natural gas demand and the course of future gas discoveries. The degree of security benefit will depend primarily on the scale of the program and the nature of the vehicles, with flexibly fueled vehicles coupled with an extensive methanol distribution network offering maximum benefits. The benefit may also depend on the extent that the United States acts to promote the entry of more secure suppliers into emerging methanol markets. Because the transition to methanol fuels will be expensive, and because methanol could remain more expensive than gasoline for many years, its energy security and other potential benefits, in relation to its costs, should be weighed carefully against alternative means to achieve the same benefits.

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[15] See Deluchi, M.A., Sperling, D., and Johnston, R.A., "Transportation Fuels and the Greenhouse Effect," University of California UER-180, December 1987. If the most efficient methanol production facilities were used and the efficiency of methanol vehicles were maximized, some reduction in greenhouse emissions would result. Also, if the methanol were produced primarily from gas that otherwise would have been vented or flared, substantial reductions in greenhouse emissions would occur. However, it seems likely that the rising worldwide use of natural gas *with or without methanol use* will substantially reduce venting and flaring, so that most methanol production in the future will not be responsible for reducing this practice.

The scale of a methanol program is critical to its national security benefits because the benefits of a small-scale program may be correspondingly small. The benefits usually attributed to a small scale program are (1) that a limited program can serve as a laboratory to develop and fine-tune technologies and marketing strategies, putting the United States a few years up the learning curve if it had to respond to a long term crisis in oil supply, and (2) that a small scale program could serve as a symbol to OPEC, a reminder that an attempt to use their oil power as a weapon could backfire. Given the slow turnover of the fleet and the massive infrastructure requirements for emplacing a methanol fuels system, however, the value of moving a few years up the learning curve, though clearly of use, is limited. And because current OPEC members appear quite aware of the availability of longer term substitutes for oil and seem genuinely interested in oil market stability, future crises seem more likely to be created by radical governments that will not be readily swayed by the existence of a "reminder"-size methanol fuels program.

At a larger scale, a methanol fuels program could reduce the United States' overall demand for oil and its level of oil import dependence. This could reduce the primary economic impact of an oil disruption as long as the prices of methanol did not rise in lockstep with oil prices -- a real possibility, especially if remote fields provided the bulk of the feedstock natural gas. Also, a large-scale methanol fuels program -- perhaps coupled with similar programs in other countries -- could reduce pressures on world oil supplies, reduce OPEC market dominance, and lessen the potential for future market disruptions. Further, the threat of rapid expansion of the program would be far more credible after the basic distribution infrastructure was widely emplaced and economies of scale achieved.

Even if it is used in large quantities, methanol is strategically attractive as a gasoline substitute only to the extent that the potential supply sources are different from the primary suppliers of crude oil, and/or to the extent that natural gas markets remain more open than oil markets to competitive pressures. Table 1 compares the market shares of oil and gas production and reserves by region in 1985. The primary difference between the distribution of oil reserves and gas reserves is that Eastern Europe and the Soviet Union hold a dominant position in gas but not in oil, and OPEC holds an important position in gas but not nearly to the same extent as in oil. A recent study of potential methanol supply sources concludes that, assuming widespread methanol-for-gasoline substitution, OPEC and the Eastern Bloc nations would likely capture at least 75 percent of the supply market.[16] Table 2 shows the proven reserves and potential methanol supply capacity of the primary suppliers, as estimated by this study. This distribution of suppliers does imply a diversification of market share in liquid fuels away from OPEC and the Middle East. However, it seems unlikely that policymakers would consider the projected shift in market power towards the Eastern Bloc as a positive factor in U.S. energy security. On the other hand, the addition of new sources of transportation fuels, even if they are not major market powers, would add somewhat to the stability of the world market for transportation fuels.

There is some question about how to interpret the projections in Table 2. Even if the distribution of methanol suppliers evolved as projected, the market power associated with this distribution may be considerably different than in the oil market. Because the degree of development of known resources is much lower for gas than for oil, new gas production capacity may be obtained from many more sources than can new oil production capacity, at least for the next several decades. For the foreseeable future, therefore, any concerted effort on the part of a group of nations to manipulate natural gas supplies and prices would likely elicit a ready supply response from new sources. This should weaken the market power of the Middle Eastern and Eastern Bloc nations even though they hold the preponderance of gas reserves. Also, the substantial number of undeveloped gasfields around the world gives the United States the opportunity to promote development of secure methanol sources by targeting investment to selected areas. Such a strategy would be a departure from past trade policy but would respond to existing national security concerns.

An important factor in determining the national security implications of a substantial shift to methanol use in transportation is the *magnitude* of worldwide development of gas resources. At moderate levels of development, there will always be available potential sources of incremental supply to block market manipulation; high levels of development might eventually tighten supplies, giving market power to the remaining holders of large reserves. The magnitude of development will in turn depend on the scale of any shift to methanol in the United States, the extent to which the shift becomes a worldwide phenomenon, and the development of other uses of natural gas in the world market. A worldwide surge in natural gas development seems quite possible given concerns about the greenhouse effect,[17] growing recognition that natural gas is a cleaner fuel than its fossil competitors, and recent improvements in gas combustion technologies (for example, more efficient gas turbines for electricity generation). Such a surge opens up the possibility that excess development and production capacity will come to reside in a few nations, as it does now in the oil market. However, this would not occur for several decades, at the earliest, and might not occur for far longer, if ever, if new gas production technologies open up new, large gas resources to development.

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[16] Chem Systems, Inc., "A Briefing Paper on Methanol Supply/Demand for the United States and the Impact of the Use of Methanol as a Transportation Fuel," prepared for the American Gas Association, September 1987.

Aside from questions about methanol supply, the nature of methanol fuel development in the United States will decide methanol's energy security benefits. For example, there are substantial security differences between a strategy favoring dedicated vehicles and one favoring flexibly fueled vehicles. A commitment to flexibly fueled vehicles (FFVs) would allow the United States to play off the suppliers of oil against methanol suppliers, and would avoid the potential problem – inherent in a strategy favoring dedicated vehicles – of giving up one security problem (OPEC instability) for another (instability in whichever group of countries becomes our methanol suppliers). However, a fleet of flexibly-fueled vehicles attains important leverage against energy blackmail only if the supply and delivery infrastructure is available to allow them to be fueled exclusively with methanol, if this becomes necessary. Because FFVs don't *require* widespread availability of an alternative fuel supply network to be practical during normal times, adoption of an FFV-based strategy is likely not to include simultaneous requirements for massive infrastructure development. In fact, because dedicated vehicles are likely to have performance and emissions advantages over FFVs, most policymakers are likely to view FFVs as only a stopgap measure on the way to a dedicated fleet. Here, energy security considerations appear to conflict with air quality goals.

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[17] As noted elsewhere, natural gas produces less carbon dioxide than competing fossil fuels *per unit of energy*.

The CHAIRMAN. We have after this panel three more witnesses, so we had better limit ourselves to about two minutes.

Let me just ask you one question. Can you be sure that methanol would increase our energy security, or is it possible that the opposite result could ensue?

Mr. PLOTKIN. First of all, we very deliberately said under certain circumstances it would increase our energy security. For example, if we were to move quickly to dedicated vehicles and we targeted our supply to certain areas, going for very large plants, each of those plants would service over 2 million vehicles. If one of those plants went down in the near term, before we really had diversified our sources of supply, we could run into a problem.

Now over the longer term, I think it is pretty clear that if we have a very large-scale program, we would have certain benefits from it. I do not think there is really any doubt as to that, except in the very long term, when you could actually, with high gas demand, run into basically the same kind of situation that you have today with the oil markets. We do not really expect to see anything like that—a concentration of market power in just a few nations—for at least three to four decades.

So I think you have a pretty reasonable window of opportunity to improve your energy security.

The CHAIRMAN. Senator McClure.

Senator MCCLURE. I want to get back to this question of cost, because I see in your testimony something quite different from what we got from EPA. Am I not correct?

Ms. STUNTZ. Senator, we are acutely aware, perhaps even more than EPA, of the dangers and risks in trying to project the price of oil next month, let alone ten years from now.

We do think that the feedstock for methanol, natural gas, and probably to a lesser degree, even coal, will be influenced by the price of oil. They are not going to move totally separately.

So for that reason and also because when you are dealing, as we are, in many of these foreign countries, with government-controlled, government-owned resources who may or may not act in ways that we would think are economical since they have other reasons to enter into particular arrangements——

Senator MCCLURE. Let me refer to specific figures on page 4 of your statement. It says, "For natural gas based methanol, the analysis shows that, depending on the assumed price of natural gas and return to the investor, methanol can be produced at plant gate cost using current technologies at a cost that ranges from under 40 cents per gallon to over 50 cents per gallon."

Now that is your statement, and that is on a volumetric basis, not a Btu equivalency basis.

Ms. STUNTZ. It is on a volumetric basis, not on a gasoline equivalency basis.

Senator MCCLURE. You would adjust that upward by 50 percent if methanol is half as energy efficient as gasoline? That would give you a price of 60 to 75 cents per gallon before taxes? Is that correct?

Ms. STUNTZ. That is correct.

Senator MCCLURE. Gasoline prices are much lower than that today, is that not correct?

Ms. Stuntz. At the plant gate, I am not positive and I turn to Dr. DiFiglio, who is the Director of our studies on these alternative fuels, for his advice.

Dr. DiFiglio. Thank you. Senator, if you take the cost projections that we have provided in our testimony and scale those up to what we believe, including taxes, would be a price for M85 at the pump, we would be talking about 80 cents per gallon.

Now, the consumer cost of M85 would depend on the fuel equivalency of the vehicle. Now, if you did not assume any efficiency advantage——

Senator McClure. What is the cost of gasoline at the pump, using the same analysis?

Dr. DiFiglio. The cost of gasoline would be around $1.10 a gallon at the pump.

Senator McClure. You are talking about 80 cents a gallon at the pump for methanol?

Dr. DiFiglio. For M85, but you have to use more M85 than gasoline so the consumer cost of M85 under these calculations would be $1.40 a gallon to travel the same distance that you would on gasoline.

Senator McClure. So you are getting to $1.40 as compared to slightly over a dollar for gasoline?

Dr. DiFiglio. In terms of the amount of mileage driven, yes.

Senator McClure. Thank you.

The Chairman. Senator Rockefeller.

Senator Rockefeller. Thank you, Mr. Chairman. Please respond as quickly as possible. Just in terms of the last question, the cost of methanol, you say it is $1.40. I have to assume that is before volume reaches a significant amount, and secondly it is at the beginning of the technology process curve, right?

Dr. DiFiglio. That is correct, senator. With advanced technology plants, the cost would be below $1.20 a gallon and be competitive with gasoline. Between 1995 and the year 2000 we certainly expect that the price of gasoline could be well above the price of methanol at $1.20 per gallon.

Senator Rockefeller. Thank you. Dr. Friedman, do you believe that reformulated gasoline is the most cost-effective way to go in terms of air quality benefits, more so than alternative fuels?

Dr. Friedman. I am not sure how you——

Senator Rockefeller. Then tell me that you do not believe that.

Dr. Friedman. We have no information on reformulated gasoline and I am sorry——

Senator Rockefeller. That is the point I am leading to. How can you come to any conclusion about reformulated gasoline when there has been no test, nobody has any idea what the cost will be, nobody knows anything about it, nobody even knows what it means?

Dr. Friedman. We have to agree with you and I am sorry that somehow you came to that conclusion from our testimony. We do not mean to imply that we had the information about——

Senator Rockefeller. Would you agree that nobody understands anything about what reformulated gasoline means?

Dr. Friedman. Well, we certainly do not and that is about as far as I can say.

Senator **Rockefeller**. You are aware that a California panel, including oil companies, has found that methanol is the cost-effective approach to air quality strategy?

Dr. **Friedman**. Senator, cost effective seems to be in the eye of the beholder.

Senator **Rockefeller**. Well, just my question.

Dr. **Friedman**. Yes, the panel's conclusions were that it was cost effective. However, the dollar costs were not much different than our conclusions of what those costs would be.

Senator **Rockefeller**. The final point, not a particular pleasant one: I am told by the principal consultant that you used for your study, which is Sierra Research, and the name of your study was "Catching our Breath"——

Dr. **Friedman**. That is the name of our ozone study, yes.

Senator **Rockefeller**. That they also, at exactly the same time as they were doing consulting for you were doing consulting for Chevron and in fact they are the principal consultant to the oil industry—a principal consultant. Is that true? Does it trouble you?

Dr. **Friedman**. Senator, we did not use Sierra's conclusions on the cost-effectiveness of methanol in our report. That was our own work. We used their work for the ability to control gasoline vehicles.

Second of all, Sierra does work for the California Air Resources Board, the Environmental Protection Agency, and for our agency, as well as many private corporations.

Senator **Rockefeller**. Fair enough. Thank you, Mr. Chairman.

The **Chairman**. Thank you, Senator Rockefeller. Senator Burns.

Thank you very much. We appreciate your testimony.

We would like to do the next three witnesses as a panel, and that is Mr. Donald R. Buist, the Director of Automotive Emissions and Fuel Economy of Ford Motor Company, Dr. Theodore R. Eck, Chief Economist of Amoco Corporation, and Dr. James MacKenzie, Climate, Energy and Pollution Program of World Resources Institute.

So let us begin with Dr. Buist.

STATEMENT OF DONALD R. BUIST, DIRECTOR, AUTOMOTIVE EMISSIONS AND FUEL ECONOMY, FORD MOTOR CO.

Mr. **Buist**. Thank you, Mr. Chairman, members of the Committee. Thank you for the opportunity to present our views on alternative fuel proposals.

Ford has been a long-term supporter of alternative fuels and we believe that such fuels should be an integral part of the Nation's clean air program.

While we began this work in earnest with a view toward energy diversity, over time our focus broadened to include clean air considerations as well.

Since the early 1970s, automotive exhaust emissions requirements have focused essentially on vehicle design as a means of reducing pollutants. The regulations have been designed to limit what comes out of the tailpipe, with almost no attention to the composition of the fuel used.

We are now approaching the limit of what can be accomplished with tailpipe controls in combination with today's fuels. Today's vehicles emit, from an emissions standard point of view, 96 percent fewer hydrocarbons, the major smog-producing pollutant, than early 1970 model vehicles. The California standards adopted by the House Health and Environment Subcommittee, which represent a formidable technical challenge, will reduce hydrocarbon emissions by only an additional 1 percentage point.

The time has come to acknowledge that what comes from the tailpipe at these low emission levels is strongly influenced by what goes into the fuel tank. You ask that we comment on the various alternative fuel approaches. We believe the following concepts are key to a successful start of a clean fuels program:

First, we should not try to make up our mind today on which fuel is the winner. Rather, the legislation should specify criteria and let all potential clean fuels compete on an equitable basis.

Second, there needs to be a centralized public fact-finding by EPA that assures that we have the most complete answers possible to questions of air quality improvement, impacts on health and global warming, and fuel availability. This information should serve as a basis for identifying eligible clean fuels.

Third, people are likely to need incentives to purchase alternative fuel vehicles. Ford market research has shown that consumers are concerned about such new technology, durability, reduced driving range, fuel availability and cost.

Fourth, widespread availability of alternative fuels is critical to develop consumer demand and achieve the desired air quality benefits, and fifth, while manufacturers should have the capability in place to produce alternative fuel vehicles, manufacturers cannot be held responsible for guaranteeing specific sales volumes.

Of the proposals under consideration, the House Environment Subcommittee amendment comes closest to meeting these criteria. The amendment preserves the President's original proposal, and the amendment requires manufacturers to certify to EPA that they have the capacity to produce, distribute and offer to sell the required volumes.

In order to assure that customer orders can be met at the volumes provided for in the amendment, auto manufacturers will have to spend millions of dollars to develop and engineer alternative fuel vehicles, put in place manufacturing facilities, make commitments to suppliers to ensure availability of components, and establish marketing and sales programs. All of this action would be clearly spelled out to EPA in advance of the program.

There is a growing consensus that alternative fuels show promise for reducing ozone. For example, California has estimated that methanol emissions are about 50 percent less reactive than gasoline emissions. Further, gasoline blended with small quantities of oxygenates such as ethanol or methanol will help reduce carbon monoxide emissions. Natural gas may qualify as a cleaner fuel for use in some centrally-fueled fleets, and electric vehicles may be a longer-term approach.

In addition, reformulated gasoline may hold substantial promise for air quality improvements, particularly if reformulated gasoline could be available for use in vehicles already in the hands of consumers.

For more than 20 years, Ford has pursued research on methanol, ethanol, compressed natural gas, liquefied petroleum gas, and electric vehicles, because alternative motor fuels have both energy and environmental benefits.

For example, while the near-term source of methanol is likely to be off-shore natural gas, more widespread use of methanol could provide an incentive to produce this fuel using domestic raw materials.

This morning, it will be announced that Ford and other domestic manufacturers are joining with 14 oil companies in a comprehensive research and testing program to evaluate a variety of alternative fuels, potentially including ethanol, methanol, natural gas, and petroleum-based reformulated gasolines.

The initial phase of this research program, which is to start immediately, will seek to determine the emissions air quality effects and relative cost-effectiveness of using these fuels.

In summary, Ford agrees that alternative fuels show promise for helping to meet the Nation's environmental and energy challenges. An alternative fuel program is likely to have substantially more air quality benefits than a tightening of automotive tailpipe emissions standards beyond the California levels adopted by the House Subcommittee.

For our part, Ford is taking the actions that will assure that the vehicle technology is ready to permit alternative fuels to play a role in helping more areas attain national air quality goals.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Buist follows:]

Testimony of Donald R. Buist

Director, Automotive Emissions and Fuel Economy Office
Ford Motor Company

Before the Senate Energy and Natural Resources Committee
October 17, 1989

Mr. Chairman, thank you for the opportunity to present our views on alternative-fuels proposals.

Ford has been a long-term supporter of alternative fuels, and we believe that such fuels should be an integral part of the nation's clean air program. While we began this work in earnest with a view toward energy diversity, over time our focus broadened to include clean air considerations as well.

Since the early 1970s, automotive exhaust emissions requirements have focused essentially on vehicle design as a means of reducing pollutants. The regulations have been designed to limit what comes out of the tailpipe with almost no attention to the composition of the fuel used.

We are now approaching the limit of what can be accomplished with tailpipe controls in combination with today's fuels. Today's vehicles emit 96 percent fewer hydrocarbons -- the major smog-producing pollutant -- than early 1970s models. The California standards adopted by the House Health and Environment Subcommittee, which represent a formidable technical challenge, will reduce hydrocarbon emissions by only an additional one percentage point.

The time has come to acknowledge that what comes out the tailpipe at these low emissions levels is strongly influenced by what goes into the fuel tank.

You asked that we comment on the various alternative-fuels approaches. We believe the following concepts are key to a successful start of a clean-fuels program:

- First, we shouldn't try to make up our mind today on which fuel is the winner. Rather, the legislation should specify criteria and let all potential clean fuels compete on an equitable basis.
- Second, there needs to be a centralized public fact-finding by EPA

that assures that we have the most complete answers possible to questions of air quality improvement, impacts on health and global warming, and fuel availability. This information should serve as the basis for identifying eligible clean fuels, so that the energy and auto industries will have clear notice as to what will be expected of them.

- Third, people are likely to need incentives to purchase alternative-fuels vehicles. Ford market research has shown that consumers recognize the potential air quality benefits of these fuels and vehicles, but are concerned about new technology, durability, reduced driving range and uncertain fuel availability and cost.
- Fourth, widespread availability of alternative fuels is critical to develop consumer demand and achieve the desired air quality benefits.
- Fifth, while manufacturers should have the capability in place to produce alternative-fuels vehicles, manufacturers cannot be held responsible for guaranteeing specific sales volumes.
- Sixth, early programs must focus on flexible-fuel vehicles, to assure that vehicle purchasers do not face restrictions in mobility while the fuel infrastructure is being put in place.

Of the proposals under consideration, the House Environment Subcommittee amendment comes closest to meeting these criteria. The amendment preserves the President's original proposal by targeting the same volumes of alternative-fuel vehicles -- 500,000 in 1995, increasing to 1 million in 1997. But while the original proposal held manufacturers responsible for specific sales volumes year after year, the amendment requires manufacturers to certify to EPA that they have the capacity to produce, distribute and offer for sale the required volumes.

In order to ensure that customer orders can be met at the volumes provided for in the amendment, auto manufacturers will have to spend millions of dollars to develop and engineer alternative-fuels vehicles, put in place manufacturing facilities, make commitments to suppliers to assure availability of components, and establish marketing and sales programs.

There is a growing consensus that alternative fuels show promise for reducing ozone-forming pollutants. For example, California has estimated that methanol emissions are about 50 percent less reactive than gasoline emissions. Gasoline, blended with small quantities of ethanol, methanol, MTBE or ETBE can help reduce CO emissions. Natural gas may qualify as a cleaner fuel for use in some centrally-fueled fleets. And electric vehicles may be a longer-term approach that will be particularly appropriate for central-city delivery systems.

Reformulated gasoline may hold substantial promise for air quality improvement. This air quality improvement potentially could be achieved even more quickly than that derived from other alternative fuels if reformulated gasoline could be available for use in vehicles already in the hands of customers.

Because alternative motor fuels have both energy and environmental benefits, Ford has pursued research on methanol, ethanol, compressed natural gas (CNG), liquefied petroleum gas (LPG) and electric vehicles for more than 20 years.

We have some 600 methanol vehicles and about 30 flexible-fuel vehicles now in field service. These vehicles are capable of operating on ethanol, methanol, gasoline or any combination of these fuels with a single fuel tank and no action on the part of the driver. Another 200 flexible-fuel vehicles will be delivered this year and we are hoping to put more than 2,500 in service over the next several years. These flexible-fuel vehicles are one solution to the problem of assuring an orderly transition while a new fuel infrastructure is developing. Although our U.S. development efforts have focused on methanol, we have extensive experience with the design and operation of ethanol-powered vehicles in Brazil.

We have substantial experience with compressed natural gas (CNG). Ford CNG programs include a dual-fueled passenger car, a dedicated CNG concept car, and a test fleet of 27 dedicated CNG Ranger trucks -- which were leased to gas companies for five years and have accumulated up to 150,000 miles.

We also have done extensive work on electric vehicles. Since 1982, Ford has conducted a $20 million, electric vehicle research program, a joint effort by Ford, General Electric, several battery manufacturers and the U.S. Department of Energy.

I previously mentioned that alternative-fuels offer potential environmental benefits -- such as reducing automotive ozone-forming pollutants. However, each of these fuels also have disadvantages as compared with conventional gasoline. The alcohol fuels have lower volatility, making the vehicles harder to start in cold weather, less energy per gallon, which reduces driving range and are more corrosive. Ethanol is very expensive to produce. Use of ethanol and methanol results in higher formaldehyde emissions than gasoline, requiring further development of emissions control systems. Natural gas has a relatively low energy density, which results in significantly reduced driving range. In addition, expensive compression systems are needed for refueling CNG vehicles. The range of electric vehicles is still very limited and overnight recharging is still required.

These fuels can also offer long-term energy benefits. For example, while the near-term source of methanol is likely to be offshore natural gas, more widespread use of methanol could provide an incentive to produce this fuel using domestic raw materials.

This morning it will be announced that Ford and other domestic manufacturers are joining with 14 oil companies in a comprehensive research and testing program to evaluate a variety of alternative fuels, potentially including ethanol, methanol, natural gas and petroleum-based reformulated gasolines.

The initial phase of the research program, which is to start immediately, will seek to determine the emissions, air quality effects and relative cost-effectiveness of using these fuels. This research is significant because it will not only look at the amount of hydrocarbons produced but also at the kinds of hydrocarbons produced -- all of which we will relate to air quality improvement.

In summary, Ford agrees that alternative fuels show promise for helping to meet the nation's environmental and energy challenges. A clean-fuels vehicle program is likely to have substantially more air quality benefits than a tightening of automotive exhaust emissions standards beyond the California levels adopted by the House subcommittee. For our part, Ford is taking the actions that will assure that the vehicle technology is ready to permit clean fuels to play a role in helping more areas attain national air quality goals.

The CHAIRMAN. Thank you very much.
Dr. Eck.

STATEMENT OF DR. THEODORE R. ECK, CHIEF ECONOMIST, AMOCO CORP.

Dr. ECK. Thank you. I submitted a written statement, but I will try to just briefly summarize. It sound like everyone has agreed that Congress should set the standards for air quality, but not specify the specific fuels. The fuels that would compete are methanol, CNG and reformulated gasoline.

In the case of methanol, it is clear from our studies the material is going to be more expensive than gasoline. We estimate 25 to 50 cents a gallon more expensive for methanol than gasoline. It sounds similar to the estimates made by the OTA and DOE.

It is not at all clear to us that methanol is cleaner burning than gasoline in the existing fleet, and the problem we run into is the advocates of methanol compare methanol in a vehicle that we have not yet built with the current average performance of the gasoline fleet. More on that later.

Finally, methanol does not exist in large volume in the world. We would have to build huge new plants, an immensely large investment, to manufacture, transport and distribute the methanol.

Quite frankly, I just do not understand the logic of the program, unless methanol indeed is going to be cheap, because it is really sort of the problem of, you can take the horse to water but you cannot force it to drink. Who is going to buy these methanol vehicles, if methanol at the pump costs 25 cents or 50 cents, a higher price than gasoline?

In contrast, CNG—compressed natural gas—in our judgment should be cost-competitive with gasoline, needs no government subsidies, no special programs or whatever, particularly for fleet vehicles. CNG is always going to be cheaper than methanol, because we are going to make the methanol from the natural gas itself at very, very high cost.

CNG, everybody agrees, is a much cleaner fuel than methanol and so our basic guess is that in a competitive market situation, CNG will always be preferred just on the basis of cleanliness alone, and we indicated in our judgment CNG will be cheaper. Also, CNG will come from North American sources. We have plenty of available natural gas to meet whatever reasonable expectation there is of how much CNG we are going to need in U.S. fleet vehicles.

Finally, reformulated gasoline. The point to remember here, it is the only fuel we have that can improve emissions from the 150 million automobiles and trucks we have on the road right now, the only option that we have, and we can make considerable improvement in how we do formulate gasoline and this will achieve significant reductions in carbon monoxide, in ozone from older vehicles and also from newer vehicles, but the primary benefit, again, would be from these older vehicles.

Again, very little additional investment is required and all of that is in the United States, rather than overseas, to manufacture reformulated gasoline. It seems to me there is a real point of contention between how the EPA arrived at their cost of methanol and how the rest of the industry analysts have come up with their numbers, and the real problem, first of all they are assuming that somehow in the world there is immense amounts of gas that we are flaring, or venting, or not using. It is true that there is a lot of gas, but they are in very small volumes at any individual site.

Now, in the case of Alaska, admittedly we have a great deal of gas in Alaska that we are reinjecting. We have gas available in Canada. It is our judgment all of that gas is going to be put into pipelines and brought down here into the United States and we are going to use that gas for homes and for businesses, and probably directly in vehicles as CNG. There is no economics in making methanol into what we think is going to be high value, high value natural gas in Alaska, high value natural gas in Canada.

Overseas, we indicated there are pockets of gas that are not being used, but if you are going to build a world scale methanol plant, you have got to have a world scale gas field somewhere around it, and this is really the problem with the EPA study.

They assume that somehow they are going to build the world's biggest gas to methanol plant. You are talking about a plant that is four times bigger than any plant we have ever built. That is going to require drilling new gas wells, and we estimate a $1 billion methanol plant that is going to require $1 billion in new gas wells.

The point in reference is that Saudi Arabia, a major source of natural gas in the future as well as now, they have to drill gas wells when they need additional gas. They are using all of the currently-available gas for reinjection or for manufacture of electricity from natural gas.

Finally, we believe that there has been considerable underestimate of the capital cost involved in building plants overseas. It might be that somebody would be willing to invest for 10 percent in the United States, but nobody is going to build a methanol plant in the Middle East at a 10 percent rate of return on investment. It just is not going to happen.

Another major source of undercosting in the EPA study is not appreciating that we have to move around at least twice as much material in the form of methanol than we do crude oil to manufacture gasoline, which means twice as many tankers per gallon, twice as much pipeline capacity, twice as many tanks, and so on, and again, the error in the estimate in the EPA study is in the order of two to three times.

They have made that much of an optimistic statement, so what we really have in their study is the assumption of far lower prices or cost of natural gas than we are going to actually get, lower cost of building the plant, lower cost to distribute.

So it should be no surprise that they came up with a cost of methanol which incidentally just happens to be equal to gasoline. They finally got it down to the equivalent of gasoline. But again, using everybody else's assessment, we do see a much higher cost.

Our judgment is that the best—that methanol is a good material. The best thing to do with methanol, however, is use it in natural gasoline, in gasoline as a fuel component in the form of MTBE.

MTBE is half methanol and half refinery material. It is a great product. It is very high octane, it reduces ozone emissions, CO emissions and so on, and our real belief is that we are going to use the entire world's supply—available supply of methanol to manufacture MTBE to meet gasoline requirements in the United States and Europe and probably Japan.

Next, turning to the issue of CNG, as I indicated, CNG is by far and away a cleaner, better fuel in all respects than methanol. We have experience, which has not been alluded to yet, with CNG. There are at least half a million compressed natural vehicles on the road in the world compared to less than 1,000 methanol vehicles. We have confidence that CNG will work.

The methanol does not have the infrastructure for distribution that we have. The gas available in the United States, we have the pipelines in place. All we really need is the compressors. That is all we have to do, is just put in a compressor, and that is why I am particularly optimistic about seeing natural gas penetrate the fleet market, because we can locate compressors in facilities for the buses and trucks and taxis and so on and make this fuel competitive and effectively available.

Another advantage of natural gas is we can make a dual fuel vehicle which will actually perform in terms of emissions better than a gasoline vehicle. Our initial methanol vehicle would be methanol plus gasoline, but would not give any improvements in efficiency or air quality. It would just have the capacity for burning methanol, for whatever value there is to that.

But in contrast, if we had a vehicle that would burn both CNG and gasoline, it would be considerably cleaner burning when it was burning natural gas as opposed to gasoline alone. We think that most people, most individuals, are going to want dual fuel vehicles.

Most of us that have one car are not going to want a car that can burn CNG only, or methanol only, because if we take them out of the area where this material, this fuel is being supplied, of course, it will not be able to be fueled and it will not go very far.

Another advantage of natural gas over methanol is that it has much higher inherent octane. CNG has 130 octane, compared to what was testified as less than 100 octane for neat methanol. This allows us to do all sorts of nice things in the design of the engine.

We can design, we are designing a natural gas fired truck and bus engine that effectively will achieve the same efficiency as a diesel engine. That engine is being manufactured, will be made available, will be on the road and will be very efficient and extremely clean, by far and away the cleanest engine of any fuel available on the market.

Finally, reformulated gasoline has been alluded to. We fully expect reformulated gasoline to be manufactured. In 1995, there is just no doubt in my mind, we are going to have a lot of reformulated gasoline available.

First of all, our current gasoline is doing a good job. It is already stated that the 1990 automobile emissions are only about 5 percent of what the pre-control vehicle was, but we can make significant reductions and improvements in this last 5 percent with reformulated gasoline.

In addition to improving the gasoline, we will be improving the vehicle, and the improvements in the vehicle will include better catalytic converters, but I think most importantly, better sensors and better, really, combustion computer controls right on the vehicle that allow it to use gasoline more efficiently, to result in lower emissions.

So a combination of reformulated gasoline with improved vehicles we believe will make a major contribution to improvement of air quality.

So if we assume a situation where the Congress provides the leadership on the air quality standards, the market solution, in all probability, will be CNG for fleet vehicles and reformulated gasoline for most private automobiles or most private vehicles.

We believe the combination of these two fuels will meet or exceed the President's or whatever the Congress does pass as the air quality standard in a way that provides the best reliability of service and performance for the American consumer.

Thank you.

[The prepared statement of Dr. Eck follows:]

T. R. Eck Testimony on Alternative Fuels before the United States Senate Committee on Energy and Natural Resources[1]

Senator Johnston, and Members of the Committee on Energy and Natural Resources:

Summary

New automobiles have less than 5 percent of the tailpipe emissions of pre-control vehicles, and alternative fuels are being proposed to reduce the remaining pollution. The costs and benefits of these fuels must be carefully analyzed before final specifications are established. The competitive market, rather than mandates, should be allowed to provide the most efficient solution.

Amoco Corporation believes that government mandates forcing the use of a particular alternative fuel for cars and trucks should be avoided. Amoco and other gasoline producers are planning to join with the major automobile companies to conduct a scientific study comparing reformulated gasoline with methanol fuels in dual-fueled vehicles. Data will be available by July of 1990, which will be provided to the public sector for review. These data should enable the government, the auto and oil companies, and the public to determine the fuels and technologies that are most economical for making further improvements in air quality.

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[1] Testimony given by Theodore R. Eck, Chief Economist of Amoco Corporation, on October 17, 1989, at a hearing in Washington, D.C.

There are a number of concerns in regard to using methanol as an alternative transportation fuel. A switch to methanol to supply the alternative-fueled vehicles proposed in President Bush's Clean Air Plan would require construction of many new methanol plants in foreign countries dependent upon supplies of foreign natural gas, foreign labor, and possibly foreign capital. About twice as much methanol would need to be imported as the volume of gasoline displaced. We are concerned about the toxicity of methanol and that its use as a motor fuel could lead to an increased number of accidental poisonings. No transportation infrastructure exists for storing, distributing and marketing methanol as a motor fuel, and this infrastructure would be costly to provide.

Compressed natural gas and reformulated gasoline are two other alternative fuels that are frequently discussed. It is quite possible that these fuels can be produced and used more economically than methanol and still provide the desired air quality improvements. The free market should be allowed to determine the most effective and efficient way to meet emission goals.

The President's Alternative Fuels Program

President Bush has proposed that the nation's urban areas with the highest levels of ozone pollution be required to replace a portion of their motor vehicles with new vehicles that operate on alternative fuels. Nine major urban areas would be affected, including Los Angeles, New York City, and Chicago. These nine ozone non-attainment areas would be required to incorporate into their population of cars and trucks up to one million vehicles per year which could burn alternative fuels. In 1995, the nine areas would be required to incorporate 500,000 vehicles; in 1996, 750,000 vehicles; and in 1997 through 2004, one million vehicles each year. An area would be allowed to avoid participation in the program if it could demonstrate comparable reductions in volatile organic compounds (VOCs) and toxic air chemicals through other means.

I appreciate the opportunity to appear before you today to give Amoco Corporation's views concerning the implications of a switch to methanol as an alternative transportation fuel. As requested, I will discuss implications relating to the production, distribution, storage and use of methanol, and the energy security aspects of a switch to this fuel. I will also briefly discuss some of the advantages of using compressed natural gas (CNG) and reformulated gasoline as alternative fuels.

Methanol as an Alternative Fuel

Methyl alcohol or methanol is frequently mentioned as an alternative fuel. Methanol currently is produced and used worldwide as a chemical in the manufacture of formaldehyde and acetic acid and as an industrial solvent. It is also used to make methyl tertiary butyl ether (MTBE), a gasoline component. Worldwide production capacity is about 7 billion gallons per year. Methanol can be produced from coal, but the technology of economic choice uses natural gas as a feedstock. Methanol from coal is about twice as expensive as methanol from natural gas. Unfortunately, the process using either natural gas or coal is thermally inefficient. Only about 60-65% of the BTUs in the natural gas input are recovered as methanol. Each gallon of methanol contains about half as much energy as a gallon of gasoline, which means that approximately twice as much methanol must be used to go a given distance. If the entire existing world production of methanol were used as an alternative motor fuel in the U.S., it would supply only 3 percent of current U.S. gasoline demand. This means that the proposed alternative fuels program using only methanol would require at least a doubling of world methanol capacity.

The economics of methanol production depend primarily upon the cost of the methanol plants and the cost of the natural gas charged to the plant. Methanol made in U.S. plants using higher-cost U.S. natural gas would be too expensive to compete with gasoline. Methanol plants built in some foreign countries would have the advantage of lower-priced gas, but plant construction costs overseas are generally higher than on the U.S. Gulf Coast. In order to achieve significant cost reductions, methanol "cluster" plants four times the size of current world scale plants have been proposed. It is not clear that investors will be willing to risk building such large facilities given their options. Each cluster methanol plant would cost $1 billion and another $1 billion or more might be required for development of gas fields capable of providing more than 2 trillion cubic feet of natural gas over the life of the plant. Investors will have to compare the methanol option with liquefied natural gas (LNG) opportunities. LNG could be more economic than methanol and could also provide greater marketing flexibility.

The Environmental Protection Agency has estimated costs for methanol production from such plants (four times current world-scale) and stated that these costs show methanol can be competitive with gasoline, particularly premium gasoline. The EPA estimates include returns on capital far lower than would encourage the private sector to risk building such plants. These optimistic assumptions on plant size and expected return understate methanol price by 10 to 15 cents per gallon, or about 20 to 30 cents per gallon on a gasoline equivalent basis. Remote natural gas prices of 50 cents to $1.00 per million BTUs also were assumed by EPA. Natural gas prices for such projects would have to be negotiated with foreign governments. While prices may be favorable for first plants, as demand grows, it will become more difficult to negotiate such favorable terms. Once a plant is built, it is dependent upon the availability of a specific gas stream and the political conditions within the country where it is situated. In making itself dependent upon methanol, the United States may become dependent upon foreign capital and labor as well.

Even from extremely large plants and with cheap natural gas, the cost of methanol delivered to the customer is likely to be considerably higher than the current cost of gasoline. Methanol must be shipped in tankers to ports in the U.S. and then distributed to the marketing areas where it will be sold and used. Currently, most gasoline is transported by pipeline to local distribution areas or it is produced locally from refineries using local crude oils or crude oils shipped by tankers or pipelines. No such infrastructure exists for methanol and the cost of transporting it would be substantially higher than the cost of transporting gasoline. Existing transportation facilities used for petroleum products cannot be used without significant modification. Methanol will pick up any water present in the system and this will result in diluted and highly corrosive methanol. From coastal areas, methanol would have to be shipped by railcar, truck, or barge, and eventually through expensive new pipelines, to local terminals from which it would be transported by tank truck to service stations. In all cases, the volume of methanol handled would be twice the volume of gasoline displaced, and many more tanker, railcar and tank truck shipments would be required.

EPA estimated storage and distribution costs at 3 cents per gallon of methanol for California, but these costs may be understated by as much as 5 cents per gallon of methanol for a coastal area, and distribution inland could cost an additional five to ten cents or more per gallon. Since about twice as much methanol is needed relative to gasoline, these cost numbers are doubled on a gasoline-equivalent basis, and methanol distribution costs would be two to three times or more the costs for gasoline.

As a potential transporter and marketer of methanol, we have concerns about its toxicity. It mixes in infinite proportion with water and, therefore, could be easily ingested resulting in possible blindness or in death. The material can also be absorbed through the skin. Because of the toxicity of methanol, extraordinary measures would have to be taken to prevent contamination of ground water or bodies of water as a result of spillage. This would add to the cost of methanol storage and transportation.

In order to travel the same distance as a comparable gasoline-powered vehicle, methanol-powered vehicles would have to have fuel tanks approximately twice as large as gasoline tanks. This would add to the weight and possibly the size of the vehicle and reduce miles-per-gallon efficiency. Alternatively, with no changes in tank size, cars could travel only half as far.

There is yet no conclusive evidence that methanol will achieve the purpose for which it is intended--namely, the lowering of ozone in large urban areas. Gasoline cars may be capable of achieving hydrocarbon emissions as low as those from methanol vehicles. This is particularly true in the case of reformulated gasoline with expected improvement in gasoline-powered vehicles. Lowered Reid vapor pressure of gasolines, already mandated by the government, should result in reduced evaporation and running losses from these vehicles. The small body of test work comparing methanol and gasoline-powered vehicles has shown advantage in tailpipe emissions of hydrocarbons but no advantage for nitrogen oxides emissions for methanol vehicles. Methanol powered engines produce more formaldehyde, which is a potent smog former and also is a suspected carcinogen. Properly designed new catalyst systems will be required to control formaldehyde.

An alternative fuels program designed for nine or more urban areas would initially have to use dual-fueled vehicles because alternative fuels would not be available at every location a driver might wish to go. Such dual-fueled vehicles burning methanol and gasoline may have little emissions improvement over conventional cars and may cost $300 or more than a gasoline-powered vehicle. Our national lack of experience with methanol vehicles is still another problem. People want vehicles that will start easily, can be refueled anywhere and will travel long distances reliably.

Because of the lack of extensive data comparing reformulated gasoline in gasoline vehicles and methanol fuels in dual-fueled vehicles, a group of automobile and oil companies are planning a joint scientific study with that aim. Data upon which decisions can be based regarding implementation of methanol fuels as alternatives to gasoline will be available by July of next year. The program will also test emissions from vehicles designed for methanol only, as soon as such vehicles are available.

The EPA, the automobile companies, and gasoline producers should cooperate to find the most cost effective methods of reducing pollution from motor vehicles, considering both the costs and benefits of the reduced pollution. New standards can then be established, and the free market can be allowed to find the most efficient and economical solutions. Mandated solutions requiring the use of a particular fuel and vehicle design are likely to yield non-optimal results. One of the greatest risks of a mandated alternative fuels program is that such a program could force a technology that will not meet the transportation needs of our country and will not be accepted by the public. Brazil's experience with its mandated ethanol-fueled vehicles is an example of such a failure. By now, our citizens recognize that even mandates are subject to change and they represent risky investments of both private and public capital.

A practical way to use methanol as a motor fuel is to manufacture methyl tertiary butyl ether (MTBE) and blend it into gasoline. This additive for gasoline can reduce carbon monoxide emissions from older and improperly maintained vehicles and replace a portion of aromatics as high octane components of reformulated gasoline. MTBE is made by reacting methanol and isobutylene obtained from refining and chemical operations. The compound already is widely used in gasoline in the United States and Europe.

Compressed Natural Gas as an Alternative Fuel

Compressed natural gas is another alternative mentioned in the President's Clean Air proposal. Compressed natural gas vehicles produce very low carbon monoxide and non-methane volatile organic compound (VOC) emissions, and the VOC emissions have very low reactivity. The infrastructure for moving natural gas into all parts of the nation is in place in the form of an extensive national and local pipeline network. What is lacking are refueling stations, but these can be provided for much less investment than the total infrastructure for a methanol system. On a worldwide basis there are some 500,000 CNG vehicles in use with no indicated safety problems. There are less than 1,000 methanol vehicles. CNG contains no sulfur and has an octane number of about 130 permitting a vehicle designed specifically for CNG to operate at a significantly higher level of efficiency. Indeed, CNG engines can operate at efficiencies equivalent to diesel engines. CNG engines can also be designed for lean-burn technology which will sharply reduce carbon monoxide emissions and result in even lower VOC emissions.

There are approximately 11 million fleet autos and three million fleet trucks in the U.S. and around one-fourth are located in the nine urban areas identified for alternative powered vehicles in the Bush plan. Use of CNG by fleets in the nine urban areas may be economically competitive and would provide an opportunity to evaluate the merits of this fuel. This information could provide data for determining whether CNG should be used in other areas of the country and whether it should be considered for non-fleet uses. In contrast to methanol/gasoline vehicles, CNG/gasoline flexible fuel vehicles should emit significantly lower total pollutants, particularly if CNG were always used for engine warm-up.

Another advantage of compressed natural gas vehicles is that these vehicles could be fueled from U.S. or North American gas reserves. Up to one-quarter of the alternative fuel vehicles proposed by President Bush through the year 2000 could be supplied with less than 5% of current U.S. natural gas production. Current deliverability is more than sufficient to provide this gas. Calculations indicate that for fleet use, CNG would be economic if CNG vehicles are mass produced at a cost no more than $200-$300 higher than a comparable gasoline vehicle.

Reformulated Gasoline as an Alternative Fuel

The pollution control measures already applied to cars produced since 1983 have lowered tailpipe emissions by more than 95% from precontrolled levels. Simple replacement of older vehicles in the fleet will continue to reduce emissions into the next century, according to the EPA. Changes in gasoline properties and in automobiles can help to cut away some of the last 5% of auto source pollution on newer cars. More significantly, reformulated gasoline can significantly reduce pollution from the very large number of older existing automobiles.

Some changes in gasoline can be made at fairly low cost, but other changes will be expensive. Determination of costs for the industry is another objective of the auto/oil research program I mentioned earlier. In the near future, we will reduce the volatility of summertime gasoline down to 9 pounds per square inch Reid vapor pressure, in accordance with existing EPA rules, by removing most of the butane which we normally blend with the gasoline. Reduced Reid vapor pressure will help cut running losses and evaporation. Lowering Reid vapor pressure below 9 pounds would accomplish little reduction in emissions and may even increase exhaust emissions, because this low volatility would adversely affect drivability and starting characteristics. There is very little sulfur in gasoline now, but removing more of it can help prolong the efficiency of pollution control catalysts on cars and trucks. It is possible to reduce aromatics to promote cleaner burning and reduce traces of benzene in the exhaust. Reductions in olefins may also be desirable to reduce reactivity of gasoline emissions. However, there will be a cost for reducing aromatics and olefins in gasoline and the cost must be balanced with benefits. We can also blend more MTBE into gasoline and that may help to reduce carbon monoxide emissions from older and improperly maintained cars.

Some beneficial changes may be feasible in automobiles at modest cost. It should be possible to improve the catalytic converters and to enlarge the size of the carbon canisters used to absorb vapors. It may be possible to design engines for quicker warmup and/or to heat catalytic converters more quickly to improve their efficiency. Better sensors and combustion controls may also be feasible and it may be possible to insulate the gasoline tank from the heat of the muffler and catalytic converter to reduce running losses. Changes of this nature will be evaluated in the auto/oil research program.

A major advantage of reformulated gasoline is that it would require no new investment in distribution systems. We have used gasoline for a long time in this country and we have a safe, efficient distribution system for this product already in place. We provide multiple choices of gasoline quality and the product is obtainable anywhere in the country. New automobiles produce less than 5 percent of the tailpipe pollution levels of pre-control vehicles. The continued use of gasoline and increased use of compressed natural gas will help maintain a plentiful supply of proven fuels for our nation's vehicles. Mandates to force the use of methanol, or any particular alternative fuel are likely to result in gross inefficiencies and an unhappy motoring public. The free market should be allowed to determine the most effective and efficient ways to meet emission goals, rather than mandated government programs to force or subsidize the use of particular alternative fuels.

TABLE 1

MARKET SHARES OF OIL AND GAS PRODUCTION AND RESERVES BY REGION IN 1985
(percent)

	Total Natural Gas Production	Total Natural Gas Reserves	Total Oil Production	Total Oil Reserves
North America				
Canada	5.2	2.9	3.1	1.0
U.S.	26.1	5.7	18.9	3.8
OPEC	14.6	31.6	29.2	67.9
Central/South America	4.1	3.7	8.8	9.1
W. Europe	10.1	6.5	7.4	3.1
E. Europe & USSR	34.1	43.5	20.8	8.7
Africa	0.6	0.6	3.0	1.3
Far East & Oceania	4.4	4.8	7.8	4.7
Other	0.8	0.6	0.9	0.9
TOTAL	100.0	100.0	100.0	100.0

SOURCE: U.S. Energy Information Administration, International Energy Annual 1986, DOE/EIA-0219(86), October 13, 1987.

Cited in: Energy and Environmental Analysis, Methanol's Potential as a Fuel for Highway Vehicles, Draft, OTA contractor report, February 1987.

TABLE 2

GLOBAL NATURAL GAS RESERVES AND METHANOL SUPPLY POTENTIAL FROM SELECTED COUNTRIES

	Proven Reserves(1) (Billion Cubic Meters)	Potential Methanol Supply (2) (Million Gallons)
Canada	2,800	1,750
Mexico	2,167	1,360
Venezuela*	1,751	1,100
Argentina	651	400
Qatar*	4,440	2,780
Abu Dhabi*	2,700	1,680
Saudi Arabia*	2,320	1,450
Kuwait*	1,032	640
Algeria*	3,030	1,900
Nigeria*	1,340	420
Australia	1,522	960
Indonesia*	1,400	880
Malaysia	1,400	880
Subtotal		16,850
USSR	38,500	24,200
Total		41,050

(1) Source: Cedigaz 1986.
(2) For each 2 percent of proven reserves.

* OPEC member.

Source: Chem Systems, Inc., "A Briefing Paper on Methanol Supply/Demand for the United States and the Impact of the Use of Methanol as a Transportation Fuel," prepared for the American Gas Association, September 1987.

The **CHAIRMAN**. Thank you very much, Dr. Eck.

Dr. Mackenzie.

STATEMENT OF DR. JAMES J. MacKENZIE, SENIOR ASSOCIATE, CLIMATE, ENERGY AND POLLUTION PROGRAM, WORLD RESOURCES INSTITUTE

Dr. **MACKENZIE**. Thank you very much, Mr. Chairman.

In my testimony I also comment on ethanol, but I will restrict myself this morning to methanol.

In many of the questions you have heard discussed this morning, I think the answers depend on whether the program is a big program or whether it remains a rather modest program of the sort proposed by the administration. And let me get into this, particularly as we affect both greenhouse warming and security of supply.

This problem, the substitution of methanol and other carbon-based fuels must be considered within the larger context of greenhouse warming. The U.S. accounts for about 20 percent of global CO_2 emissions; per capita levels are about five times the world average. And EPA, in its report to Congress of last fall, said that we have to reduce, globally, CO_2 emissions by up to 80 percent to stabilize the climate.

It is within that context that I think this dedication of our fleet to further use of fossil fuels does not make sense on a long-term basis.

Let me address two issues, the clean air implications of methanol and the security implications and sources of supply.

Methanol has been called a clean fuel, but it is a misnomer. Let me give you an example. The California Air Resources Board has adopted a standard for formaldehyde of 15 milligrams per mile. A methanol vehicle without any converters on it emits about 650 milligrams per mile. That is not a clean vehicle.

Formaldehyde is one of the primary concerns in the formation of ozone as these vehicles penetrate the market. The best cars that are produced now are averaging between 30 and 70 milligrams per mile, and could not be registered in the State of California. They have got a long way to go to get durable, long-term, effective catalytic converters to reduce formaldehyde levels. And if they cannot do it, then they are not going to have any beneficial ozone impact.

Secondly, the cars that have been tested so far are higher than gasoline vehicles in NO_x, emissions; consistently higher. If they cannot reduce the NOx emissions substantially, they are not going to make any impact on acid deposition as it arises from vehicles, and that is about 40 percent of the emissions of NOx, nor rural ozone. This issue came up before. There is a lot of damage being done in the agricultural states in this country from rural ozone produced by the burning of fuels, by both transportation and utilities. And it is not going to help that problem at all.

There has been little indication as to what the actual impacts on air quality would be of the President's program. Dr. Friedman mentioned it, but he did not dwell on it.

According to EPA, buried in the appendix of their recent report on methanol, complete implementation of the President's program would lead to a 1.5 percent reduction in peak ozone levels in the year 2005, and assuming methanol vehicles from then on. Neat methanol, with the most optimistic assumptions on emissions, they get a 3 percent reduction.

Are we willing to spend that much money and rearrange our whole industry for benefits that are that marginal?

And the problem is that these cars are going to be competing with ever-cleaner conventional vehicles, which means that the transportation contribution to ozone is going to go down.

The EPA says that by the year 2000 or shortly thereafter, it will be only 20 percent of the problem. As a result, even eliminating all hydrocarbon emissions is not going to make that much of an impact.

They also indicate it is a very expensive option.

The other point that came up was the so-called toxics. There was a lot of statements made about the benefits of reducing benzene.

Again, buried in the appendix of EPA's report is the estimate of what would actually occur in reduced cancers by the year 2005 from replacing 20 percent of the cars and trucks with methanol trucks, neat methanol, meeting all the standards; nine cancers less in the year 2005.

Just to put that in context, we have about a million cancer incidences that occur each year in this country. And that is with a lot of assumptions about the actual performance of these vehicles.

So I think that the clean air benefits are marginal compared with both other things we could do and other transportation options that I think we ought to be pursuing.

Let me mention a word about greenhouse warming and the methanol sources. I think there is little disagreement that if you make methanol from natural gas that would not be flared but used otherwise, that it is roughly neutral with gasoline. There is no particular benefit.

If you make it from coal, there is a substantial penalty depending on the efficiency of the process.

The CHAIRMAN. The penalty you are talking about is price?

Dr. MACKENZIE. I am talking about CO_2 emissions per vehicle mile travelled.

If you make methanol from coal, there is going to be a lot more carbon dioxide released at the plant. You cannot just scrub it and put it in the ground. You do not have enough holes to put it into, basically. You would quickly overwhelm all industrial uses of CO_2, including secondary oil recovery and all industrial uses. You would have about twice as much CO_2 with even this modest program that is being proposed.

If you go to a big-scale program you are not going to know what to do with that carbon dioxide.

This country generates about 100 trillion cubic feet per year of CO_2; that is about five times the size of our whole natural gas industry. And you are going to have to just erect some kind of elaborate sequestering process to put it in the oceans or something. And then the impacts of that are quite uncertain as well.

So I do not think that makes a lot of sense.

Again, it becomes the matter of how big the program is. Is the program small? Then it is not going to have much of an effect on anything, air quality, security payments or security.

If it is a big program, then you start getting into those issues.

As proposed now, this program would require about a trillion cubic feet of gas as feed stock at its peak. That is about a third of the gas that is now vented. And I agree, if that gas were not vented and instead converted to methanol, it would be a clean air benefit. But as you get into a larger program, and as the price of gas goes up as a result of this sort of thing, then that gas would not be vented or flared, and then I think that the price will rise.

There is no answer to the question: Could a cartel form once methanol producers got into a big program? I see no reason at all why the producing sources could not form an association of methanol producers once this program got up.

The Chairman. Would it not be easier than OPEC?

Dr. MacKenzie. I do not see any reason why not. I mean it is going to take a lot of money to erect these facilities. Especially as you get into a dedicated methanol fleet, I think the options will be fewer on the part of consumers.

The Chairman. Well, it seems to me that oil is produced all around the world and you do not have to—you know, it is not refined or anything—to import it.

Dr. MacKenzie. It is largely a matter of price at this point. You can get decentralized sources which are smaller, and from more expensive gas. But if you want to keep the cost down, as you have just heard from the previous speaker, you are going to go to large-scale plants where the gas is secure.

The Chairman. But it looks to me like that analogy ought to be to liquefied natural gas as in Algeria, when we had all these tankers dedicated to the trade, and then they wanted to go up on their price and we had no alternative.

Dr. MacKenzie. Exactly.

Let me raise one other point. You have heard that 85 percent of the exportable gas is in either OPEC or Eastern Bloc countries. That is roughly true for gas as well as oil; it is comparable. If you have a small program, you can probably get the gas from what we would call, say, secure sources. But as you get into a larger program, as we have with our oil imports, we find that 20 percent of our oil is from these insecure sources, which poses a threat to our national security.

And I would suggest the same thing would happen there, as you get into a larger scale methanol program, that the sources would become inevitably sources that you might not want to go to.

Let me summarize my testimony, then. I think the clean air benefits are very marginal for the program as advertised. The vehicles that are now being tested do not meet the standards; they do not meet the formaldehyde standards.

The greenhouse warming effect, in a small program there might be a benefit. If you got all of your methanol under the President's program from gas that would otherwise be vented, there would be a seven-tenths of 1 percent reduction in national CO_2 emissions. But as you get beyond that source, then you are going to get a source that is neutral, with respect to greenhouse warming, when we are faced with a prospect of reducing emissions on the order of 20 percent, say, by the turn of the century or shortly thereafter.

In testimony before the Commerce Committee a few weeks ago, I presented calculations showing that if vehicle miles travelled grow at 2 to 3 percent per year for the next few decades, you would need highly efficient cars, in the order of 50 to 70 miles per gallon, soon after the turn of the century, to reduce CO_2 emissions to goals that have been proposed as national goals. I do not think that is going to happen.

And that leads me to my final observation, which is I think that, for the short term, we have got to improve fuel efficiency to deal with warming, we have got to do a lot of the things that have been talked about here, in terms of better inspection and maintenance, tightening of standards, reducing refueling emissions and so forth, and starting toward, basically, non-fossil energy sources as a long-term option, namely hydrogen and electric vehicles derived from non-fossil energy sources.

And within the last three weeks, we had a press conference, the World Resources Institute, on the Hill here, in which there was a hydrogen vehicles, which is now manufactured by Mercedes Benz; it was driven around, it works.

The problems that we face with this energy source, which produces nothing but water out of its tailpipe, is reducing the cost of hydrogen and getting better sources of hydrogen storage.

I would suggest that a greatly magnified program on batteries and hydrogen, with the sources to be derived from the non-fossil energy sources, offers a long-term perspective, which will deal with energy security, global warming and air pollution together.

Thank you very much.

[The prepared statement of Dr. MacKenzie follows:]

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STATEMENT OF

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Before the

Committee on Energy and Natural Resources

United States Senate

October 17, 1989

Mr. Chairman and members of the Committee, thank you for inviting me to testify today on the use of methanol as an automotive fuel. In my testimony I will also touch briefly upon some of the issues relating to widespread ethanol use in automobiles and trucks.

In his June clean-air message, President Bush threw his support behind the so-called clean automotive fuels to reduce urban smog. Both methanol (wood alcohol) and ethanol (grain alcohol) have been dubbed "clean fuels," but methanol has received the most attention from both Congress and state governments, particularly California. Despite current enthusiasm, there are a number of sound reasons for avoiding a crash program to widely introduce either of these alcohol fuels.

First, neither of these fuels, in and of itself, is a "clean fuel." The total environmental and pollution impacts of using alcohol fuels will depend critically on the design of the vehicles in which the fuels are used as well as the processes and raw materials, such as coal, from which they are derived. Even with very optimistic assumptions about the performance of methanol vehicles, the clean air benefits of widespread methanol use would in fact be very small measured against those of ever cleaner conventionally powered vehicles.

Second, providing a sufficient amount of either of these fuels would entail unfavorable tradeoffs. In the case of methanol, using coal as a feedstock would result in very large carbon dioxide emissions, while the alternative -- conversion of natural gas to methanol -- would require dependence on foreign sources, offering no relief from the financial and security risks presently posed by imported oil. In the case of ethanol, displacing even a moderate amount of petroleum would require dedicating vast amounts of agricultural land to corn production.

Third, a large scale alcohol fuels effort would waste precious time and resources on technologies that -- because of global warming -- would ultimately prove to be dead ends.

The sources of methanol and ethanol, as well as their properties, differ markedly. The ethanol used in transportation is derived from biological sources primarily corn. We are most familiar with ethanol as an ingredient in alcoholic beverages. Unlike ethanol, methanol is quite toxic. Small amounts can cause blindness, neurological damage, and death. Less than a tablespoon of M85* ingested by a one-year old would be fatal.[1] Pure methanol used as a motor vehicle fuel also poses several safety problems. First, it burns without a visible flame; hence, the hazard to rescue workers in the event of an accident. Second, methanol is explosive in storage tanks under normal temperature conditions, while gasoline is not. Special precautions would need to be developed and used to overcome these hazards.

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* A mixture of 85 percent methanol and 15 percent gasoline. This is the form in which methanol would be introduced to the U.S. auto fleet.

Current proposals by both the California and federal governments would introduce methanol through the use of flexible or dual fuel vehicles capable of burning blends ranging from pure gasoline to M85. These vehicles would be manufactured and sold over the coming years if President Bush's proposal is adopted. Their use would probably have to be mandated in commercial fleets by federal or state regulations, given the lack of any obvious consumer benefit in performance or economics. Automobiles operating on pure "neat" methanol are not now being considered for manufacture because they pose a number of technical problems. For example, they are difficult to start at temperatures less than 40 to 50 F.

Several studies have been completed on the expected air quality impacts of methanol vehicles. In a 1987 report to the Vice President's Task Force on Alternative Fuels, EPA estimated the reductions in ozone levels that would occur in New York, Washington, D.C., and Los Angeles by introducing current and advanced technology methanol vehicles.[2] Using optimistic assumptions on methanol vehicle emissions, EPA concluded that replacing 15 percent of vehicle miles traveled (VMT) in these three cities with current-technology methanol vehicles would reduce ozone levels by about 1 percent; replacing a quarter of all VMT with current methanol vehicles would reduce ozone levels by a maximum of 1.7 percent. So-called "advanced methanol" technology was projected to achieve reductions of only 3 to 4.5 percent by the year 2000 compared with levels resulting from conventionally powered vehicles.

In September 1989, in connection with President Bush's clean air proposals, EPA released its latest assessment of the air quality impacts of methanol use.[3] The agency assumed that under President Bush's clean air proposals flexible fuel vehicles would be sold in the 1995-1999 period followed by dedicated M100 (pure methanol) vehicles thereafter. Even with optimistic assumptions on the emissions from methanol vehicles, EPA concluded that the ozone benefits would be very small. Under the President's program, EPA concluded, ozone levels in the year 2005 would be reduced by an average 1.5 percent in nine of the nation's more polluted cities. See the table on the next page. By the year 2015, the "maximum benefit," assuming the introduction of pure (and presumed cleaner) methanol vehicles beginning in the year 2000, would be an average reduction of only 3.3 percent. The small expected impact on smog levels from these methanol vehicles is largely the result of a predicted diminishing contribution of transportation to smog formation, this the consequence of ever cleaner conventionally powered vehicles.

PROJECTED CITY-SPECIFIC OZONE (VOC) REDUCTIONS
(In Percent)

AREA	2005	2015
Los Angeles	1.3	2.9
Houston	0.7	1.6
New York City	2.2	4.7
Milwaukee	1.6	3.4
Baltimore	2.0	4.4
Philadelphia	1.2	2.6
Greater Conn.	1.9	4.1
Chicago	1.5	3.3
San Diego	1.2	2.6
Typical Reduction	1.5%	3.3%

Source: Environmental Protection Agency, "Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel," September 1989, page 55.

EPA has also claimed significant health benefits from methanol use in the reduction of cancers from toxic air pollutants: "...projected reductions in the number of cancer cases as a result of a clean fuels program are significant."[4] Their estimates, however, are based on optimistic assumptions about both methanol vehicle emissions and the actual use of methanol vehicles in polluted urban areas. Assuming a very aggressive methanol program (20 percent of all cars and trucks in the 9 most polluted cities would be methanol powered by 2005, half of them running on pure methanol), EPA calculates a total reduction of 9 cancers in the year 2005. To place this in context, in 1988 there were 985,000 new cancers reported in the United States.

Reducing ozone levels using methanol would be very expensive compared with other options. A July 1989 report by the Office of Technology Assessment gave a mean value of $30,000 per ton of hydrocarbons removed from the ambient air using methanol vehicles.[5] (EPA assumes a one-for-one change between hydrocarbon emissions and resulting ozone levels.) This cost is to be compared with costs of $1,000 to $5,000 per ton for a range of other technologies such as limiting gasoline volatility ($500 per ton), capturing vapors with special fuel pumps at filling stations ($1000 per ton), or strengthening inspection and maintenance programs ($4000 per ton). According to OTA, "...by far the most expensive [method to reduce ozone levels] is replacing gasoline with methanol, at $8,700 to $51,000 per ton of reductions."[6]

It should be stressed again that EPA's conclusions on methanol's potential clean air benefits are based on optimistic assumptions about future emissions. State-of-the-art methanol vehicles have been tested extensively for their air pollution emissions by the California Air Resources Board (CARB).[7] CARB found that emissions from these cars will have to be significantly reduced just to meet California's present standards for formaldehyde and nitrogen oxides, both important ingredients in smog formation. In other words, methanol by itself, is in no sense a "clean fuel."

Consider the reductions in formaldehyde emissions that will have to be achieved. Typical uncontrolled formaldehyde emissions from a vehicle operating on neat (M100) methanol are 650 milligrams per mile.[8] Well maintained, low mileage prototype methanol vehicles have achieved about 35 milligrams per mile, a 95 percent reduction. The new California standard for methanol is only 15 milligrams per mile, requiring an additional 57 percent reduction from present technology. And some modeling studies on the potential clean air benefits of methanol have assumed emission levels of only 3 milligrams per mile, a 91 percent reduction from typical present levels. Developing durable catalytic converters that will reduce both formaldehyde and NOx emissions to levels sufficient to make methanol worth pursuing will be no simple task. Until it is accomplished no reliable conclusions can be drawn on any potential clean air benefits from such vehicles.

Methanol supporters claim that benefits to national security will arise from using methanol in place of gasoline. This would be true if the methanol were made from domestic coal, as methanol backers originally proposed. However, because coal-derived methanol would be far more expensive, the fuel that would be used in the auto fleet would be imported and made from natural gas. Unfortunately, about 87 percent of the world's exportable surplus natural gas reserves are in OPEC or the Soviet Union.[9] It is questionable whether the United States could import methanol only from non-OPEC, non-eastern bloc sources. Presumably, the feasibility would depend on the size of the methanol program, the relative prices of natural gas among diverse sources, and competing demands for the gas for other purposes. A very small import program, with the methanol imported from non-OPEC, non-eastern block suppliers, might pose few security risks but also bring few benefits.** Whatever the source of the imported methanol, it is clear that the U.S. balance of payments problem (about $40 billion of which results from petroluem imports) would not be materially helped by switching from imported oil to imported methanol.

For reasons quite aside from its unfavorable economics, coal is not a desirable source of methanol. A large coal-based methanol industry would entail significant environmental damages on two fronts. First, at the synfuels plants themselves there would be all the impacts of coal mining, water contamination, and disposal of the ash and wastes from the manufacture of methanol. Second, coal-based methanol would accelerated global warming because of the extra carbon dioxide emissions that would occur at the coal-to-methanol plant. Total CO_2 emissions (per vehicle

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**There is a close analogy here with U.S. dependency on imported oil. As in the case of natural gas, about 84 percent of world oil reserves are in either OPEC or Eastern-bloc countries. Because U.S. imports are so large, however, (40 percent of supply in 1988) more than 20 percent of total U.S. oil supply arises from OPEC sources, with a consequent jeopardy to U.S. national security.

mile traveled) would be 20 to 160 percent greater than those from gasoline, depending on the efficiency of the coal conversion process used.[10] Methanol made from natural gas would have about the same CO_2 emissions as gasoline. In short, the increased contribution to global warming from CO_2 emissions provides a strong argument against a massive long-term coal-based methanol effort.

In response to the problem of carbon dioxide emissions EPA argues that the feedstock for methanol would be associated natural gas that is now flared or vented. As a consequence, the use of methanol made from this source would result in a substantial benefit in CO_2 emissions.[11] If the methanol were made from such gas, a greenhouse benefit would indeed arise: the natural gas now flared or vented would first be used to power vehicles, resulting in a net reduction in CO_2 emissions. The problem with this argument is that flared and vented gas is more costly and less reliable a source than non-associated gas because of high gathering and compression costs due to remote locations, and variable production rates for the associated petroleum. Indeed, were this not the case, the gas would be used already as a feedstock for the chemical industry or for use as liquefied natural gas. As a result, methanol derived from presently flared associated gas would be more expensive than if made from non-associated gas, weakening the basic economic argument for the methanol effort.

Ethanol (grain alcohol) is unlikely to become a major energy source because of the huge amount of agricultural land that would be needed. Despite widespread support for ethanol in corn-growing states (85 percent of ethanol motor fuel is made from corn), the fuel contributes only a tiny fraction to U.S. energy supply, equal to less than 1/2 percent of present gasoline use. If the energy losses that occur in making this ethanol are taken into account the contribution would be even less, perhaps even negative (a net energy penalty). This is so because the energy needed to produce a gallon of ethanol is between 77 and 101 percent of the energy contained in a gallon of ethanol.[12] This inefficiency aside, to meet 1988 U.S. gasoline demand with 100 percent ethanol fuel would require planting 570 million acres in corn, an area about 75 percent greater than total U.S. cropland. The prospect of converting a significant fraction of U.S. agriculture to ethanol production makes little sense in a world characterized by ever tighter food supplies, and by a changing climate in which U.S. agriculture is expected to come out a loser. For these reasons ethanol is unlikely to ever become a major source of automotive fuel.

An alternative strategy for reducing air pollution from vehicles, enhancing national oil security, and cutting the risks of global warming would focus on more conventional means for reducing emissions in the short term and the introduction of non-fossil energy technologies for the long term. Cutting vehicle emissions can be achieved by requiring new cars and trucks to meet tighter emission standards, such as those now being adopted by California, by reducing the volatility of gasoline to reduce evaporative emissions, by capturing vapors now released during refueling, by significantly strengthening inspection and maintenance (I&M) programs for the existing fleet of vehicles, and by reformulating gasoline to make it inherently less polluting. Greatly increased fuel efficiency for new cars and trucks would help enhance national security and slow the growth of CO_2 emissions. Limited use of compressed natural gas and methanol in the heavy duty engines of buses and trucks where it can cut diesel smoke emissions could also help clear the air.

For the long haul we need to stress improved transportation efficiency and the introduction of non-fossil energy technologies. System efficiency can be increased through the use of high occupancy vehicles, the construction of heavy and light rail systems in our urban areas, and improved regional transportation planning that will de-emphasize the role of the auto in daily commuting and increase overall system efficiency.

At the same time accelerated research and development must be undertaken on non-fossil energy technologies suitable for powering the vehicles of tomorrow in a climate-stabilized world. The energy sources for the 21st century will be primarily electric, including the renewable technologies*** and, possibly, second generation, passively-safe nuclear fission. Whatever the mix, new "energy carriers" will be needed for vehicles. Two promising candidates are hydrogen, derived from the electrolysis of water, and batteries that would power land based vehicles. The World Resources Institute has just published a report, Solar Hydrogen, Moving Beyond Fossil Fuels, exploring the very promising outlook for hydrogen as a motor vehicle fuel with the electricity derived from solar sources.[13] Hydrogen and electric powered cars -- with the power and hydrogen derived from non-fossil energy sources -- would emit no carbon dioxide, no hydrocarbons, no carbon monoxide, and negligible amounts of NOx (none in the case of electric vehicles.) What is badly needed now is more research and development to reduce the costs of hydrogen and battery technologies. Incorporating the presently unpaid social costs of petroleum (particularly the pollution, climate, and security costs) into the price of gasoline and other transportation fuels would certainly help "level the playing field" and increase the attractiveness of these emerging transportation technologies.

To summarize my testimony: large-scale programs to introduce alcohol powered vehicles are not in the national interest. Such

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*** Renewable technologies include wind turbines, photovoltaic cells, solar thermal power plants, hydro dams, geothermal power plants, and high-efficiency turbines powered by biofuels.

vehicles would have few if any positive impacts on urban smog levels, carbon dioxide emissions, national security, or our balance of payments problems. Moreover, they would divert precious time and resources into paths that would ultimately prove to be dead ends because of global warming. They should be avoided.

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The **Chairman**. Thank you very much, Dr. MacKenzie.

Dr. MacKenzie, in the environmental community, can you quantify what percentage are for methanol and what percentage are against?

Dr. **MacKenzie**. I cannot. I am sorry, I do not know.

The **Chairman**. Do you know where the majority are?

Dr. **MacKenzie**. I do not know.

The **Chairman**. Mr. Buist, EPA claims that they will be able to produce a neat methanol-powered car that costs no more than a gasoline car, and they cite your testimony before Congress as a reference. Can you do it?

Mr. **Buist**. Today I have to say no, I cannot build an M100 vehicle that would run properly. We do not have the technology today to do that.

We are hopeful we will have the technology in the time frame that the President has laid out in the administration's bill to build M85 vehicles in the mid-1990s time frame. We think we have a reasonable shot at pulling that off.

The **Chairman**. Now, EPA also indicated that when optimized, a dedicated methanol vehicle will be up to 30 percent more efficient than a future gasoline car. Do you think that is correct? Others say 10 to 15 percent; do you think that is more correct?

Mr. **Buist**. EPA is talking about an optimized vehicle, and that is a vehicle in our mind that runs solely on methanol. In other words, you do not have to design that vehicle to operate equally well on methanol and gasoline, and there is no question that if you can just design that vehicle, what we call a dedicated methanol vehicle, methanol has a potential to increase the efficiency of the vehicle.

The problem we see is that you cannot embark or put this nation on a methanol program without first using flexible fuel vehicles. We have had the experience in California with some 600 dedicated vehicles. And the first thing we concluded is paranoia sets in as soon as the consumer gets in his dedicated vehicle and starts out and he realizes that he does not have a service station at every corner.

They literally will not leave the middle of L.A. and travel to the airport.

So flexible fuel has to be the bride to start the program. And when you say flexible, you have to design it so it operates equally well on both fuels.

The **Chairman**. How about power? Would you feel the power in a methanol car?

Mr. **Buist**. Yes. With the flexible fuel vehicle you get, I will say, Senator, about a 5 percent power kick when you use methanol. So there is that little incentive there to use it.

The **Chairman**. How about natural gas?

Mr. **Buist**. Natural gas, well, I cannot speak to natural gas and gasoline together. I am not sure I can get you that answer if you want. But with a natural gas dedicated vehicle, no, you do not see that kick. But it is hard to compare, because you have to literally be in the vehicle.

That 5 percent is not a big kick, so you have to be in the vehicle and switch fuels and look for that change. So our concern is that is not going to necessarily be a huge incentive for the consumer to go out and buy that vehicle; 5 percent is not that big.

The CHAIRMAN. How about maintenance on a methanol vehicle? Would it be less than gasoline?

Mr. BUIST. We do not see a difference in maintenance. Before we would market a methanol vehicle, methanol is highly corrosive, we would have to completely redesign the fuel system. But from an overall maintenance point of view, we would hope there would be basically no difference.

The CHAIRMAN. A lot less maintenance with natural gas?

Mr. BUIST. Oh, less maintenance than natural gas? That is hard to call. I might guess that they would be pretty much the same.

The CHAIRMAN. You say that you are reaching the technical limit of what can be done at the automobile tailpipe. Do not significant amounts of hydrocarbon escape from evaporation from fuel tanks, engines refueling, starting and stopping engines? Should we not be trying to expand regulation of this? Is there not great room for this?

Mr. BUIST. Yes, you are right, Senator, there are significant amounts that escape.

For instance, the single largest amount now that EPA and the industry just recently became aware of in the last couple of years are what we call running losses, or evaporative emissions that escape from the vehicle when it is running under what we would call high ozone days, 95-plus-degree temperature, high sun load days. We discovered, with today's fuel, there is a lot more evaporative emissions that are driven off the vehicle than anyone ever thought existed before.

But, at the same time, we have indicated that, in combination with the oil industry, auto and oil are working together, we can virtually eliminate that portion of the evaporative emissions. We are confident of that.

The CHAIRMAN. Dr. Eck, is there not a lot less maintenance from compressed natural gas?

Mr. ECK. I was a little surprised to hear the comment. There is no question that it is a much cleaner burning fuel. And you end up with a lot less residue. You know we have a lot more experience also with CNG vehicles. As I indicated, we have a half million vehicles on the road throughout the world, and we have seen less maintenance, and by a considerable factor.

Also I might comment that it is possible to build a dedicated CNG vehicle that would be far more efficient than a dedicated methanol vehicle, and that is because we have higher octane and we can achieve considerable higher compression ratios.

So, in terms of efficiency and emissions, a dedicated CNG vehicle would be the state-of-the-art, cleanest burning, most efficient engined vehicle we could make.

The CHAIRMAN. Now, we are talking about the economics of natural gas looking at today's natural gas prices. My guess is those prices are going to increase as we work through this gas bubble, et cetera. Now do you expect that the price of natural gas will go up and down with the price of crude oil?

Mr. ECK. Yes, we do.

Incidently, we believe that the fuel price of natural gas could double and it would still be cheaper than methanol developed for vehicle use.

The CHAIRMAN. Well, the price of methanol would also go up with natural gas.

Mr. ECK. And then the price of methanol would also go up with the price of crude oil.

The CHAIRMAN. There is no reasonable alternative to natural gas as a feed stock for methanol, is there?

Mr. ECK. Only coal, but at twice the cost.

The CHAIRMAN. Now, tell me about the potential for fleet use of compressed natural gas, percentage-wise?

Mr. ECK. Roughly 14 million vehicles in the United States are in fleet use. You know most of those vehicles we think could operate on compressed natural gas. You know I do not think there is any question about the potential for fleet use.

The real question is about your automobile and my automobile, you know, whether or not we want to have a compressor in our own garage or whether we want to equip our vehicle with the tanks and go to, in effect, a filling station/gasoline station.

But I might comment, it does seem to be working in other countries. Up in Canada, a couple of provinces are selling an awful lot of compressed natural gas for use in private automobiles, and the same thing in New Zealand. So it certainly can work.

The CHAIRMAN. Well, how about the supply?

Mr. ECK. And there is no question we have got plenty of gas for this type of application. I think we estimate it to——

The CHAIRMAN. You mean for fleet use?

Mr. ECK. I think we estimated for fleets alone that it would be roughly equivalent to 5 percent of new U.S. natural gas supplies; it is something like one TCF. And there are a lot of people in the United States that would have natural gas shut in and would just love to see another TCF of demand out there.

So there is no question we have got plenty of gas in North America to handle any conceivable requirement for natural gas for fleet vehicles.

The CHAIRMAN. Now of the 14 million vehicles, what percentage, roughly, would not be suitable for fleet use because they travel, like trucks, across the country?

Mr. ECK. Well, that is a good question. And I agree with the Ford representative that we believe that other than dedicated trucks and buses, that as we move into smaller vehicles and automobiles, most of these vehicles will be dual fuel. Most people are not going to want a single fuel capability only because of going across the country.

But, again, the good thing about CNG plus gasoline is that when it is running on CNG, it runs as a clean fuel.

I frankly see no advantage whatsoever to the manufacture of a methanol plus a gasoline vehicle. It is not a cleaner burning vehicle; you know methanol is going to be more expensive. I really do not see what is accomplished by that vehicle.

The CHAIRMAN. How about the danger of compressed natural gas?

Mr. **Eck**. Compressed natural gas, again, we have got a lot of experience with compressed natural gas. As far as I know, there is no evidence of explosions. People worry about the tanks exploding. As far as I know, there have never been any examples of these explosions actually taking place.

I think the general judgment is that—I hate to say this as a manufacturer of gasoline, but I think that CNG is a safer fuel.

The **Chairman**. Than gasoline.

Dr. **Eck**. Than gasoline.

Mr. **Buist**. If I could come back to compressed natural gas just for a second, I would like to make the committee understand that Ford Motor Company is not opposed to compressed natural gas. In fact, that may be part of our program that I just described we have announced this morning.

We are looking at all fuels, including reformulated.

The **Chairman**. You have no choice?

Mr. **Buist**. That is right. We have no choice. EPA told you we are a big part of the problem. We want to be a major part of the solution.

We do believe, though, that if you ask the Nation to embark on an alternative fuels program five years from now and you ask it to embark on, let us say, nine cities, across nine cities, which is a major undertaking, for the majority of the vehicles in those nine cities the easiest way to start is with a liquid. The infrastructure is already there. It is relatively simple to put the liquid in existing service stations. It is much simpler to ask the auto industry to use a different type of liquid fuel than to say go to a gaseous fuel where we have to practically completely redesign the vehicle to accommodate, for instance, the tanks that go in perhaps the trunk or in a pickup truck, the bed and that type of thing.

The **Chairman**. What would be the cost of a dual fuel methanol and gasoline car, the incremental cost?

Mr. **Buist**. It would probably be in the area of about $300; a pure estimate, Senator.

The **Chairman**. What do you say for CNG?

Mr. **Buist**. On a large scale, that is hard to estimate. Conversions now to CNG are in the area of $1,500 to $2,000 if you were to convert.

I quickly come back and say it would probably be less than that were we to mass produce them, but I do not really have a number yet.

The **Chairman**. Do you have any numbers on that?

Dr. **Eck**. Yes. We have been studying this issue.

I, incidentally, am heavily involved with the Gas Research Institute, and we have done a lot of work on this issue. We get numbers roughly the same as the methanol conversion. For original equipment it would be $200 to $300.

Let me comment that——

The **Chairman**. Excuse me. Let me ask you. Do you have any reason to disagree with that?

Mr. **Buist**. No. I think he agreed with my $300 for methanol.

Dr. **Eck**. For CNG also.

Mr. **Buist**. No, I disagree with that, because if you ask me to mass produce the CNG vehicle I have to start all over and build a completely new vehicle.

Dr. **Eck**. That is not true. We are talking not a dedicated only but a vehicle——

Mr. **Buist**. It does not matter if it is dedicated or not. If you ask me to run it on compressed natural gas, I have to put a large tank in the vehicle, and I have no place to put it today unless you want to move the trunk, for instance, or half of your load bed in a pickup truck.

The **Chairman**. Of course, if you have methanol you have to have a tank twice as large, do you not?

Mr. **Buist**. There is no question if we go to methanol we will have to get the tank as large as we can.

When you drive on methanol, you will have to fill up about twice as often as you drive with gasoline. There is no question about that.

The **Chairman**. How big are the relative tanks of compressed natural gas?

Dr. **Eck**. I have actually seen them and driven the vehicles, and they are back there in the trunk; but they take up a very small percentage of the trunk.

Mr. **Buist**. About half.

Dr. **Eck**. We are talking about something that was retrofitted and not a basic design. That is one of the things, frankly, we are trying to do with Detroit, is interest Detroit in designing a CNG vehicle.

Let me stress the value——

The **Chairman**. Let me ask you this first. How about energy density of cubic inches of methanol as compared to natural gas?

Dr. **Eck**. CNG is roughly the same density as gasoline in a compressed form.

Mr. **Buist**. We are seeing today about half the driving range with compressed natural gas with the tank that we use that you could use today, and there are vehicles out there running today. The driving range is about half that of gasoline. That is not to say that it could not be improved at some point in the future, but that is what we are looking at.

Senator **McClure**. That is about the same as methanol?

Mr. **Buist**. Yes.

The **Chairman**. Why do you say his figure of $200 to $300 for fleet design——

Mr. **Buist**. Only because I am saying that I would have to completely redesign the vehicle. I do not necessarily have to do as much with methanol as I do with compressed natural gas.

The **Chairman**. But you have not run those figures? You just think that sounds too low?

Mr. **Buist**. No. Without question, a rather large tank, compressed natural gas tank, has to be put on the vehicle in addition to the existing fuel tank, whereas I do not need that with a methanol vehicle. I can use the same tank. So there is no question that the vehicle will have to change dramatically versus the methanol vehicle.

The **Chairman**. Senator McClure.

Senator **McClure**. I want to get back to the question of the cold start problem. There is a cold start problem with M100, is there not?

Mr. **Buist**. Yes.

Senator **McClure**. Now can you overcome it by installing some kind of mechanism which has not yet been designed or installed? Is that probable?

Mr. **Buist**. Well, you are saying that it may be able to be invented. I would not say that it would not be able to be invented. Hopefully someone may invent that some day.

Senator **McClure**. It does not exist now?

Mr. **Buist**. It does not exist today.

Senator **McClure**. So it is not just taking off-the-shelf technology and installing it to solve that problem?

Mr. **Buist**. No, sir.

Senator **McClure**. Do you have the same problem with M85?

Mr. **Buist**. No, we do not have the same problem to the same degree. We feel confident that by the mid 1990s we will be able to adequately take care of the cold start problem with M85. That 15 percent gasoline in there appears to take care of the issue.

Senator **McClure**. Have you done as much research with ethanol as you have with methanol?

Mr. **Buist**. No, but let me follow that up, Senator, by saying that when we concluded that we should direct our attention at a flexible fuel vehicle, we also concluded that that vehicle ought to run equally well on methanol and ethanol and gasoline. So our vehicles today are designed to run on those three fuels.

Senator **McClure**. Just to refresh my memory, we have been using two for one ratio here today in comparing methanol and gasoline. My recollection was that methanol is better than 60 percent equivalent with gasoline. Is that correct?

Mr. **Buist**. That is right.

Senator **McClure**. Two to one is just easier to say.

The **Chairman**. Could I interrupt for just one second? Excuse me. I would like to submit Senator Nickles' statement for the record, and I will have some questions in writing.

If I may take leave with thanks to you, I will let Senator McClure continue.

Senator **McClure** [presiding]. Ethanol, if I recall correctly, is 15 to 20 percent better than methanol with respect to Btu equivalency; is that correct?

Mr. **Buist**. I think it is slightly better, Senator. I am not sure if it is 15 or 20.

Senator **McClure**. In the low 60s for methanol and in the high 70s for ethanol.

Mr. **Buist**. I think you are right.

Senator **McClure**. Dr. Eck, you are nodding your head. Am I correct?

Dr. **Eck**. You are correct.

Senator **McClure**. Dr. Eck, do you agree with respect to the cold start question?

Dr. **Eck**. There is no question there is a cold start question on the M100. That is why there is no indication that anyone is going to manufacture this one right away because it will not start. Again, that is why we start out initially with the M85 program.

The problem I have with the M85 program is I do not really see what we are accomplishing versus a reformulated gasoline alternative.

Mr. BUIST. Senator, may I speak to that?

Senator McCLURE. Sure.

Mr. BUIST. From our perspective, we think we are accomplishing the following. The administration asks that the auto industry step up to a new set of standards across the country, a new set of lower tailpipe emission standards. We are going to step up to that.

They next said that that was not enough from the auto industry for nine key areas of this country because they are in deep trouble with respect to ozone compliance. As Mr. Rosenberg pointed out, there are two steps you could take. You could say let us drop the standards and half again, or let us embark on an alternative fuels program.

We do not know how to drop the standards. We are confident we would not be able to meet the second tier of lower tailpipe standards in those nine cities, or across the Nation for that matter.

We think we have a reasonable shot at doing an alternative fuels program, be it methanol or reformulated gasoline, however that works out, in those nine key cities. So we think that is the advantage, and we are also told that methanol is much less reactive and, therefore, you actually get better ozone control out of that than you do in going to the second tier.

So that is where we come out.

Senator McCLURE. Dr. Eck.

Dr. ECK. Again, it is a problem of comparing M85 with conventional gasoline rather than reformulated gasoline in a vehicle that is designed to use it.

I think the other issue is what do we do with the existing fleet of vehicles that we alluded to earlier. The biggest contribution that we can make to clean air is to improve the emissions of 150 million vehicles that are already out there. Cleaner fuels is one way to do that, and another way to do it is to improve maintenance inspections and that sort of thing.

I think most studies indicate that by far and away the most cost effective approach to clean air is to worry about the existing vehicles.

Senator McCLURE. You said in your earlier statement, Dr. Eck, that the industry can reconstitute the methods by which you produce gasoline today and produce cleaner fuel.

If that is true, why are you not doing it now?

Dr. ECK. Well, our first initiative was to get the lead out of gasoline.

Senator McCLURE. Well, at least General Motors had that in mind.

Dr. ECK. Well, we did that and in the process we put in some materials, of which aromatics happens to be one of them. To restore the performance of the gasoline to maintain the high octane performance of gasoline, we put in aromatics. Aromatics have very high octane and good drivability, but, you know, they do introduce questions which we are now addressing about emissions.

Senator **McClure**. You knew that when you put them in.

Dr. **Eck**. I do not think there was a large amount of technical data available on ozone, for example, as the major air quality problem. We were worried about carbon monoxide, NOx and so on, and we did a great job on that. The current automobile, as we indicated, has eliminated 95 percent of the pollutants that we had identified as being something to be worried about.

Senator **McClure**. All I am really getting at in my own mind is there is a cost that is involved in making changes. You have all alluded to that. There are benefits, sometimes, as Dr. MacKenzie has indicated, very small benefits perhaps, but nevertheless a benefit and a cost.

Now you tell us you know how to do things better with gasoline than you are now doing, but you are not doing them.

Dr. **Eck**. Again, as you say, they do cost money. As I indicated, the industry will be reformulating gas. I do not think there is any question that that is the direction that the industry will go.

The most cost effective alternative, I think, is the issue of addressing the volatility of gasoline. It was testified that 70 percent of the pollutants that are generated from gasoline come from evaporative processes. It is not just evaporation of gasoline in a tank. It is actually running losses. When the engine is running there is evaporation. This can be, I think, addressed in a cost effective manner by reducing the vapor pressure, the evaporative characteristics of the gasoline itself. I think that will happen.

Senator **McClure**. Again, I am not asking a "when did you stop beating your wife" question, but obviously you are so confident that you can do it, I keep asking myself and repeat if you are that confident that you can do it, why have you not done it?

Dr. **Eck**. Again, in the past the major investments we made were taking the lead out of gasoline. That was a major, major, major hurdle, and it is only in the most recent debates that public attention has centered on ozone. We understand where ozone comes from now. I think that is why, as indicated here, we are working with the automobile industry right as we speak today to try to come up with the most cost efficient way of meeting our environmental objectives.

Senator **McClure**. Again, I am not trying to put you on the spot, and I am not unduly critical of either you or your particular company.

It seems clear to me, however, that much of what you are saying today we knew at least ten years ago. I remember when the Clean Air Act Amendments of 1968 were going through the Committee on Environment and Public Works. All of this same information was available to us, and that was 21 years ago. I knew it then, at least I was told by experts, and I believed what the experts were saying.

That is not by way of criticism, but it is to say that if we expect either the auto industry or the petroleum industry to achieve certain things, we are going to have to tell you what it is we expect you to achieve.

Dr. **Eck**. I guess we agree with that. We are very sympathetic to the idea of the Congress stipulating what air quality standards should be and then we meet that standard.

I guess what I was trying to say is that we will reformulate gasoline. We do not know what the most cost effective way of doing that is because, again, that is a question of not only the fuel but the vehicle; what combination of fuel plus the vehicle will give us the cleanest emissions at the most acceptable public cost.

That is just exactly what we intend to do, to come up with the best formula for gasoline and the best formula for controls on board the vehicle.

Senator **McClure**. If I understood your earlier statement, you also do not agree with EPA on the expected cost of methanol fuels?

Dr. **Eck**. Not at all, and I know of no one else that does, either. It sounds like everyone came up with essentially the same answer, that they are off by a factor of 25 to 50 percent.

Senator **McClure**. I have to tell you that I do not believe EPA's figures, either. I guess as my colleague was telling me a moment ago, your face indicated you did not agree. I might as well state it so the record shows. I do not believe those figures, either.

I think they reasoned backwards. In order to sell a program, they had to come up with a cost that was acceptable, so they came up with a cost that was acceptable; therefore, the public and therefore the Congress is apt to adopt it, and we will find out what the costs are later.

I think we do that repeatedly around here, so I am not necessarily totally condemnatory of that particular feature of our policymaking. It has even been suggested that maybe Congress uses smoke and mirrors on budgets, which I also think is probably correct because we have an objective that we are trying to achieve, so we achieve it.

I think there is some of that that leads to this whole debate about which direction we ought to go and what our program ought to be.

Dr. MacKenzie, if I recall correctly, while in theory combustion of hydrogen produces only water, in practice there is also some NOx produced.

Dr. **MacKenzie**. Very tiny amounts in an internal combustion engine. In the longer term, I think fuel cells would probably double the fuel efficiency of the vehicle, and then it would be just water.

Senator **McClure**. Indeed, if we move to that technology and if we can afford to produce to do so.

Dr. **MacKenzie**. Right.

Senator **McClure**. Those are still very large, looming ifs, are they not?

Dr. **MacKenzie**. Yes. It is a matter of price. It might cost $2 per gallon equivalent to get hydrogen rolling. In Western Europe and Japan they pay $2 to $3.

Senator **McClure**. One of the reasons that I persisted in looking at ethanol, and I know this does not please the petroleum industry at all, is the fact that we spend some $25 to $30 billion per year in farm subsidies. $25 or $30 billion could change the economics of ethanol quite a little.

Dr. **MacKenzie**. In my testimony I do indicate a recent Congressional Research Service report which says that it take 70 to 101 percent as much energy to make the ethanol as you get from it.

Senator **McClure**. There are also some studies that indicate that that is not correct.

Dr. **MacKenzie**. I am unaware of those.

Senator **McClure**. I can provide that for you, and you can tell me why it is wrong.

Dr. **MacKenzie**. There was one on carbon dioxide emissions that said it was less because they contributed some of the carbon dioxide in making ethanol to some of the byproducts that would otherwise have to be made, so that the oil, the corn oil and the animal feed took some of the carbon dioxide penalty away from the ethanol.

As far as I know on fuel, I have never seen any.

Senator **McClure**. I saw one just last week. Again, I will give it to you so you can tell me why it is not right.

Thank you all very much. The committee is adjourned.

[Whereupon, at 12:50 p.m. the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

J. BENNETT JOHNSTON, LOUISIANA, CHAIRMAN

DALE BUMPERS, ARKANSAS
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HOWARD M. METZENBAUM, OHIO
BILL BRADLEY, NEW JERSEY
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FRANK M. CUSHING, STAFF DIRECTOR FOR THE MINORITY
GARY G. ELLSWORTH, CHIEF COUNSEL FOR THE MINORITY

United States Senate
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, DC 20510-6150

October 30, 1989

The Honorable William G. Rosenberg
Assistant Administrator for Air and Radiation
U. S. Environmental Protection Agency
401 M Street, S.W.
Washington, D. C. 20460

Dear Mr. Rosenberg:

Thank you for your letter of October 20, 1989, following your recent appearance at the hearing held by the Committee on Energy and Natural Resources on October 17, 1989, concerning the role of methanol as a potential alternative fuel. Your views concerning the impact of this provision in the President's Clean Air Act and the implications of this program on energy policy are greatly appreciated.

In order to assist the Committee in its consideration of this issue, I am attaching additional questions for inclusion in the hearing record. I would appreciate your sending your responses to Jim Bruce of the Committee staff by November 21, 1989.

Again, thank you for your testimony. I look forward to receiving your additional comments.

Sincerely,

J. Bennett Johnston
J. Bennett Johnston
Chairman

JBJ/jbg

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF CONGRESSIONAL
AND LEGISLATIVE AFFAIRS

Honorable J. Bennett Johnston
Chairman, Committee on Energy
and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed, for insertion in the hearing record, are EPA's responses to questions which were forwarded to Administrator Reilly following the October 17, 1989 hearing on methanol held by the Committee on Energy and Natural Resources.

Please feel free to contact us if we can be of any further assistance.

Sincerely,

Charles M. Hassett
Acting Director
Legislative Analysis Division

Enclosure

cc: Honorable Howard M. Metzenbaum
Honorable James A. McClure
Honorable Frank A. Murkowski

JAN 24 1990

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Senator Johnston Questions

Question 1a

The Administration's proposal certainly is perceived as being tilted toward methanol, but you indicate it is fuel neutral because the fuels will all be compared against a performance standard.

How will you set that performance standard? The bill gives EPA tremendously broad discretion -- couldn't you set it to knock out everything but methanol if you really wanted to do that?

Aren't you saying to these other fuels like CNG, "Trust us."

Response

Our goal would be to set emissions performance standards that would provide significant air quality benefits while at the same time giving as many alternative fuels as possible the opportunity to compete for inclusion in the program. These performance standards would be established in a formal rulemaking process that would permit maximum public input and comment. We stated before your Committee on October 17th that we would aim for a set of emissions performance standards that would provide 30 to 40 percent reductions in both hydrocarbons and toxics in the near term and 80 to 90 percent reductions in these pollutants in the long term. Automobile manufacturers would be free to sell any combination of vehicle technology that meets these standards. We believe that ethanol, methanol, compressed natural gas, liquefied petroleum gas, and electricity all have the potential to meet these standards. In fact, certain fuels such as electricity and compressed natural gas may well provide somewhat greater emission reductions than ethanol or methanol. The only candidate fuel for which there is uncertainty about meeting the type of emissions performance standards described above is reformulated gasoline. We look forward to hearing from the oil industry regarding specific gasoline reformulations and to evaluating the emission reductions available with such reformulations.

Question 1b

Will your initial performance standard be something that uses M85's emissions characteristics as the benchmark?

Response

Our initial, or phase one, emissions performance standard of 30 to 40 percent reduction in both hydrocarbons and toxic emissions is approximately what we believe can be achieved with M85 fuel. But, we believe this standard could also be met with ethanol, CNG, LPG, and electricity as well, and possibly reformulated gasoline. We consider it important to set standards that provide emission reductions while maintaining fuel neutrality.

Question 1c

Aren't you opposed to the Hall-Fields amendment in part because it ties you to an M85 standard and won't let you raise the performance standard higher to the characteristics of M100 later on?

Response

One of the major reasons we oppose the Hall-Fields amendment is that it does not allow us to move to a phase two performance standard that would yield greater emission reductions.

Question 2

If you had it to do over again, would you have done anything differently in your proposal so as to achieve fuel neutrality?

Response

No, we believe S.1490 is fuel neutral and provides a level playing field. We define a level playing field as a situation in which all candidate clean fuels have a fair and equal opportunity to compete based on their merits. The proposal is fuel and technology neutral. It requires EPA to establish emissions performance standards based on "the long-term reductions in ozone-producing and toxic air emissions that... may reasonably be anticipated to result from the use of clean alternative fuels formulated to provide maximum reductions of such emissions." Any combination of fuel and engine technology that could meet these emissions performance standards would be eligible for inclusion in the clean fuels program. Candidate fuels include ethanol, methanol, compressed natural gas, propane, electricity, and reformulated gasoline.

Questions 3a & 3b

Your prepared statement says that alternative fuels are now priced competitively with gasoline "and we would expect this situation to improve as alternative fuel demand increases providing for production and distribution economies of scale.

DOE has a draft report on methanol production costs that projects the gasoline equivalent price of M100 will be $1.50 per gallon from existing technology plants and $1.20 - $1.32 per gallon from advanced technology plants. Moreover, OTA sees methanol as being more expensive than gasoline.

Isn't there substantial room for doubt about what the methanol price will be?

Responses

Yes, there is room for doubt about future methanol prices. There is, of course, also uncertainty about future gasoline prices as well as about the price of all other candidate fuels.

All one can do is to project future prices based on analyses that take into consideration the best information that we have. We performed an analysis of methanol fuel and concluded that the realized methanol gasoline-equivalent price to consumers could be $1.05 to $1.09 per gallon in methanol flexible fuel vehicles and somewhat lower in optimized methanol vehicles. This is 18 percent lower than DOE's average estimated range of $1.20 to $1.32 per gallon for advanced technology plants. DOE uses a higher capital recovery factor, higher plant operating cost, and much higher retail markup.

We strongly disagree with OTA's methanol economics assumptions. They did not really study the issue in detail, but rather took a "snapshot" of market prices at the time of their project (market prices are much lower today). This ignores many issues associated with economies of scale in future methanol fuel production and distribution. For example, they assumed a methanol production cost of 40 to 60 cents per gallon, while our midpoint estimate of delivered port price is 35 cents per gallon (Department of Energy projections for large, advanced scheme plants are in the 35 to 40 cent range). OTA completely ignored recent work that assumes the economies of scale in methanol fuel production that would be available in a high-demand program. OTA also used very high distribution and service station markup costs that are not appropriate for a clean fuels program like that contained in the Bush bill that could involve economies of scale in fuel distribution. It is our understanding that OTA is now preparing a more detailed analysis of methanol fuel economics.

Question 3c

DOE has a recent study on the foreign experience with alternative fuels that suggests that subsidies are usually required to make alternative fuels work. You mentioned Brazil and New Zealand -- they heavily subsidized their alternative fuels, didn't they?

Response

It is our understanding that Brazil and New Zealand have both provided substantial subsidies for ethanol and compressed natural gas, respectively. The philosophy behind the President's clean fuels proposal is to establish that a certain fraction of new vehicles in our dirtiest metropolitan areas should be cleaner than the rest of the new vehicles, in order to help these areas achieve reductions in ozone precursors and air toxics. The fuel that these vehicles would be fueled with would be determined by comparative advantage. We would expect that the most cost-effective fuel or fuels would win out. Fortunately, we believe that some of the candidate fuels will be cost competitive with gasoline, given the necessary economies of scale.

Question 3d

What happens under your proposal if methanol is the clean fuel of choice, but it turns out to be more expensive than gasoline? Don't the States have to subsidize methanol under your proposal? It not, why will the public buy methanol?

Response

We agree that most consumers would not utilize a clean fuel if it were considerably more expensive than gasoline. Some higher cost may be acceptable to some consumers if the more expensive fuel yields higher performance, as would be expected, for example, with methanol in a flexible fuel vehicle (premium gasoline accounts for about one-quarter of all gasoline sold today). In any case, it is not clear what the price of methanol or any other clean fuel will be relative to that of gasoline in the late 1990s. The concept embodied in the Bush bill is within the requirement to use clean fuels in a prescribed percentage of new vehicles to let the various clean fuels compete and the clean fuel that is most cost effective will win out. To that extent, if methanol or other clean fuels do in fact turn out to be more expensive, the States with affected urban areas are obligated by the bill to ensure that use of the clean fuels is economic from the standpoint of the vehicle user, which would involve subsidies. A state, for example, could adopt fuel sales requirements similar to the automobile sales requirement.

Question 4

One EPA report indicates that gasoline and methanol mixed together act synergistically to increase the rate of methanol absorption into the skin. What concerns do you have about the health and safety of garage mechanics who may work with M85 on their hands and clothes?

Response

One study with humans has shown that methanol's rate of absorption into the skin is higher with M85 than with M100. Garage mechanics should not routinely come into contact with M85 or vehicle fuel of any kind. M85 is not as good a solvent for oils and greases as gasoline, so the frequency with which it is used for degreasing or cleaning hands is likely to be less than with gasoline even without efforts to train mechanics to avoid it. Splashes of M85 on the skin should evaporate quickly, and as a result, are not of long enough duration to be of major concern. Furthermore, the risk is controllable since skin absorption even with M85 is not instantaneous. Even immersion of a hand in M85 for a full minute would not exceed the added body burden of methanol obtained from drinking four cans of a diet beverage. (Diet beverages contain the artificial sweetener aspartame, 10% of which becomes methanol in the body.) Only if methanol is maintained in contact with the skin, such as with methanol soaked clothing, are concerns likely to arise. Education will be necessary to cover cases with potential prolonged exposure.

Question 5

Have you ever asked the company that supplies all the methanol to the Indianapolis 500 what problems they have in handling methanol?

Response

No, we have not talked directly to the company that supplies methanol to the Indianapolis 500. We have talked to a number of organizations that routinely handle methanol both in the chemical industry and in various vehicle demonstration programs. Methanol is very toxic if ingested, but normal shipping and handling do not present any unique problems. It is also relevant to note that methanol exists in a wide variety of consumer products, such as windshield washer fluid and dry gas, and that certain dietary products, like some soft drinks and certain vegetables, yield methanol as a metabolic byproduct.

Question 6

To what extent did global climate change considerations enter into EPA's analysis of methanol as an alternative fuel?

Response

The primary environmental concerns driving the President's clean fuels program were tropospheric ozone and air toxics. However, EPA was also concerned that any solution to these problems not result in significant increases in greenhouse gas emissions. As outlined in our Special Report on Methanol, we believe that methanol produced in the near term from natural gas, at least part of which is currently being vented or flared, can significantly lower net greenhouse gas emissions relative to gasoline. In the long run, methanol from coal could potentially lead to significant increases in greenhouse gas emissions. However, if CO_2 recovery and disposal technology is developed and employed, advanced technology methanol vehicles would have roughly the same and potentially even less impact on long-term global warming than vehicles using gasoline from crude oil.

Question 7

Whatever we do with new cars using alternative fuels, can one make a good case for immediately replacing leaded gasoline with low volatility, oxygenated gasoline for all old cars? Isn't a disproportionate part of the pollution problem coming from those cars?

Response

Yes, older cars cause a disproportionate share of total vehicle pollution. It is for that reason that the Administration bill included provisions which can be taken in the relatively near term to reduce emissions from cars on the road today. These include further reductions in gasoline volatility and the use of oxygenated gasoline in cities which have serious air pollution problems. By the late 1990's most of the pre-1975 models will be off the road and at that time the most cost effective means to further reduce vehicle emissions will likely be cleaner-burning fuels.

Question 8

Will the President's clean air proposal inhibit the ability of new domestic refineries to produce gasoline? Are you aware of any other federal or state proposals to do so? Does the U.S. need modification of federal environmental law to increase domestic refining capacity? Does the federal government need authority to facilitate siting and construction of environmentally acceptable domestic refining capacity?

Response

There are no new requirements in the President's CAA proposal that would inhibit the construction or modification of domestic refineries to produce gasoline. Under the current Act, major new construction that would significantly increase emissions would be subject to nonattainment new source review requirements, or to prevention of significant deterioration requirements, (if located in an attainment area). The President's proposal makes no significant change to these requirements.

We are not aware of other Federal or State air pollution-related proposals that go beyond these requirements.

We do not believe that modification of the Clean Air Act is needed to increase domestic refining capacity, or that the Federal Government should pre-empt State laws to facilitate new domestic refining capacity.

Senator Metzenbaum Questions

Question 1

If the volatility of all gasoline today were reduced to 9.0 RVP through removal of butane or related compounds, how much reduction would there be in total reactivity-adjusted VOC and air toxic emissions (including tailpipe, refueling, running losses, hot soak, and diurnal, etc.)?

Response

Comparing emissions in 1990, with a 9.0 psi fuel versus a 10.5 psi fuel, over a temperature range of 75-95°F, total VOC from motor vehicles would be reduced roughly 22 percent, with air toxic emissions reduced roughly 10 percent. Please note that the VOC from both fuels are considered equally reactive. Also, this is just an example. Actual reductions would be dependent on local conditions.

Question 2

If, in addition to lowering volatility to 9.0 RVP, the aromatics currently produced at the refinery to enhance octane were not produced, how much reduction in reactivity adjusted VOCs and air toxics would result? (Include same sources of combustion and evaporative emissions listed above.)

Response

Whole gasoline has an aromatics content of about 35 percent by volume. Currently, approximately 40 percent of these aromatics (15 percent of whole gasoline aromatics) are produced in the refinery, primarily through reforming. The effect of eliminating these reformer aromatics on exhaust VOC emissions is not clearly understood and efforts, both inside and outside EPA, are underway to provide more information. However, given available data, it is difficult to project any reduction in exhaust VOC emissions due to reduced aromatics. Thus, any improvement in reactivity adjusted VOCs must come from reduced reactivity. Preliminary analysis indicate that aromatics, on the whole, have only slightly higher than average reactivity. Thus, substituting other gasoline components for aromatics as a group may have little effect on average reactivity or total reactivity. Removing only the most reactive aromatic species and replacing them with lower than average-reactivity non-aromatics would reduce total reactivity, but this sort of substitution does not correspond with the way aromatics are generated in a refinery. It is not well known how aromatic substitution would affect exhaust emissions of the highly reactive olefins.

EPA's Special Report on Methanol outlines the air toxics impacts of a base gasoline of 35 percent aromatics and 9 RVP, as well as the effect of M85 and M100 vehicles. Table 1 shows this information plus the impact of a reduction of gasoline aromatics to 20 volume percent. As can be seen, the reduction in gasoline aromatics reduces air toxic related cancer incidences by 17 percent, versus the 44 and 93 percent reductions achievable via clean fuel vehicles. The reductions are given as precise numbers in the table. However, due to various uncertainties in the assumptions used to calculate the numbers (e.g., uncertainties in exposures and potencies), the number should not be treated as exact.

Table 1

Air Toxics Impact of Various Fuels*

Pollutant Source	Year 2005 Base Light-Duty Gasoline Motor Vehicle Cancer Cases in Nine Cities***	Per Vehicle Percent Reductions		
		20% Aromatic Gasoline**	FFVs on M85	M100
Exhaust Benzene	11.4	45	77	97
Evaporative Benzene	1.5	0	67	100
Running Loss Benzene	1.6	0	69	100
Refueling Benzene	1.9	0	14	100
Gasoline Vapors	11.7	0	14	100
Exhaust 1,3-Butadiene	19.8	0	64	99
Exhaust POM	15.4	43	72	99
Direct Formaldehyde	1.3	0	(+600)	(+200)
Indirect Formaldehyde	4.4	0	43	80
Total Incidence	69.0	57.2	38.6	5.2
Total Percent Reduction		17	44	93

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* EPA Special Report on Methanol, pg. 61.

** Memo, Paul Laing, "Gasoline Aromatic Reductions Needed to Achieve Toxic Reduction Benefits of Clean Alternative Fuels Program," September 28, 1989.

*** Assumes gasoline vehicles meet standards proposed by the President.

Question 3

How would each of these modifications affect the yield per barrel of crude, cost of refining, and octane?

Response

Typically, operation of a reformer results in a valuable (liquid) product yield of 70-80 percent of the liquid feed to the unit. Eliminating the reformer (i.e., the aromatics produced in the refinery) would result in a 25-34 percent increase in liquid yield. Given that reformate represents about 35 percent of all gasoline, eliminating the reformer would increase the yield of gasoline from a barrel of crude oil by 9-11 percent. However, the resulting gasoline octane would be reduced approximately 8 octane numbers.

The cost of eliminating the reformer includes the cost of lost octane (which can be made up at approximately 1¢/gal of full gasoline per octane number); the cost of lost hydrogen production (approximately 0.6¢/gal); and a credit of about 0.65¢/gal due to the increased gasoline yield less the cost of lost light-ends. Thus, the overall cost to reduce aromatics produced in the refinery is about 8¢/gal. These figures are very preliminary and a detailed study has been contracted with Bonner & Moore to better determine the cost of reducing gasoline aromatic content. This will be completed in three to four months.

Question 4

What are the octane requirements of the vehicles on the road today? Please specify the percentage of vehicles with the various octane requirements.

Response

We have not been able to perform a comprehensive review of individual automotive owner's manuals, but it is our understanding that well over 90 percent of all new vehicles require "regular" unleaded gasoline, which generally has a pump octane number (the average of research octane and motor octane) of 87. The remaining vehicles require somewhat higher octane, with some vehicles requiring pump octane as high as 93.

Question 5a

If alcohols were produced from natural gas or agricultural products, combined with a derivative of butane to produce MTBE or ETBE, and mixed 15-17 percent with all gasoline as formulated in question one and two above:

How much reduction in VOC's, air toxics, and CO would result?

Response

For RVP-matched fuels, the effect of adding oxygenates to gasoline depends almost solely on oxygen content. Blending 15-17 percent MTBE and ETBE into gasoline would result in oxygen contents of 2.7-3.1 and 2.4-2.7 weight percent, respectively.* Thus, MTBE and ETBE use would reduce exhaust VOC emissions by 4.1-4.6 and 3.5-4.0 percent and would reduce CO emissions by 16-18 and 14-16 percent in newer closed-loop vehicles, respectively. Other sources of VOC, such as evaporative emissions, are essentially unaffected with matched RVP.

The effect of these ethers on air toxics depends on whether they are simply added to whole gasoline (i.e., splash-blended) or are blended at the refinery. Since MTBE is currently blended at the refinery and splash-blending would waste the octane increase, it will be assumed here that the blends you describe would be blended at the refinery with adjustments to other component streams. The primary adjustment would be a lowering of reformer severity or reformate usage with the primary result being a lowering of aromatics content. The use of one volume percent ether is expected to allow a reduction of somewhat less than one volume percent of aromatics. Thus, the reduction of aromatics described in the previous question already accounts for the aromatics reduction (and resulting air toxics reduction) likely to be associated with ether use. In fact, use of ethers is the most likely way refiners will make up for the octane loss described in the previous question.

The only other effect of ether use on air toxics would be due to their general effect on exhaust VOC emissions. Since the oxygen appears to cause more complete combustion under certain operating conditions, emissions of all VOC species are expected to decrease. Thus, if exhaust VOC emissions were reduced 5 percent, for example, then EPA would expect that exhaust-related air toxics emissions would decrease 5 percent, as well. With 9 RVP and 20 percent aromatic gasoline, exhaust toxics represent nearly 70 percent of total air toxic emissions. Thus, 15-17 percent MTBE and ETBE usage would decrease air toxic emissions by 2.8-3.2 and 2.4-2.7 percent, respectively.

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* Under current EPA unleaded fuel waivers, MTBE and ETBE use are limited to 15 and 13 volume percent, respectively.

Question 5b

What would the octane of the gasoline be?

Response

The blending octanes (R+M/2) of MTBE and ETBE are 110 and 111, respectively. As described above, for regular unleaded gasoline with an (R+M/2) octane of 87, a loss of 8 octane numbers due to removal of 15 volume percent of the aromatic content would result in an octane of 79.* Blending in 15-17 percent MTBE and ETBE would result in roughly 84 octane gasoline in both cases. The net effect is a loss of 3 octane numbers due to the reduction in aromatics content and the addition of oxygenates.

Questions 5c & d

How much would this reformulated fuel cost at today's prices using:

1. spot priced crude oil and domestic natural gas used for methanol feedstock;
2. spot-priced crude oil and domestically produced ethanol;
3. foreign methanol?

How much would the 15-17 percent ether additives cost using the above assumptions?

Responses

Addressing the cost of the ethers first, the current price of MTBE is roughly 80-85¢ per gallon domestically with crude oil prices near $20 per barrel. This price essentially represents MTBE's value as gasoline extender (50-55¢ per gallon) plus its octane value (31¢ per gallon). The MTBE used domestically is primarily produced in the U.S. from domestic natural gas and refinery isobutylene. However, some MTBE is already being made from field butane (from natural gas liquids), which requires conversion to isobutylene prior to reaction with methanol to form MTBE. This raises the cost of MTBE significantly. Since most of the natural sources of refinery isobutylene are already dedicated to MTBE production, the isobutylene for either MTBE or ETBE in the scenario described in your question will have to come from field butanes.

From EPA's Special Report on Methanol, at current natural gas prices of around $1.40 per million Btu in the Gulf Coast, methanol could be produced for around 32¢ per gallon in large, new, multi-train methanol plants. This cost is above methanol's current spot price, but probably approximates more closely current contract prices. However, the problem is that U.S. natural gas prices are not expected to remain this low in the future, particularly if large amounts were used to produce MTBE. At $3.50 per million Btu, methanol costs would increase to 53¢ per gallon and MTBE costs would roughly approach today's prices. Thus, MTBE made from field butanes and domestic methanol should be able to compete at today's MTBE prices of 80-85¢ per gallon. Foreign methanol should remain in the 30-35¢ per gallon range (delivered to the U.S.), so MTBE from foreign methanol should remain very competitive at today's prices. At concentrations of 15-17 volume percent, MTBE blends would cost roughly 4.5-5.1¢ per gallon of gasoline.

Current ethanol prices are around $1.10 per gallon. EPA is nearing completion of its Special Report on Ethanol, which will contain projections of future ethanol prices. However, until that report is finalized and published, use of the current ethanol prices should be adequate. Assuming prices of $.30 and $1.10 per gallon for methanol and ethanol, respectively, ETBE will cost about 25¢ per gallon more than MTBE. ETBE's slightly higher octane is worth about 1¢ per gallon more that MTBE and its lower blending RVP is worth about 4¢ per gallon. Thus, use of ETBE from unsubsidized ethanol would cost about 3.0-3.4¢ per gallon of gasoline more than MTBE at 15-17 volume percent. If the blenders tax credit were made available to ethanol used to produce ETBE, then, assuming a 34 percent corporate tax rate and 0.42 gallons of ethanol per gallon of ETBE, then the credit would be worth 17¢ per gallon of ETBE, nearly equating the cost of the two ethers. The ETBE costs projected here assumes similar chemical kinetics compared to MTBE production and should be considered only first approximations.

Starting with 9 RVP gasoline, which is EPA's preferred base case since we have already committed to it in the President's proposal, the cost of the reformulated gasoline as described above would be:

1. Roughly no cost for eliminating reformer aromatics ignoring octane losses;

2. Roughly 5¢ per gallon for MTBE use and 5-8¢ per gallon for ETBE use; and

3. Roughly 3¢ per gallon to make up the remaining octane loss for a total of 8-11¢ per gallon.

Question 6

How much North American natural gas and new infrastructure would be needed today, in 1995, 2000, and 2005 to make sufficient quantities of MTBE to add to all gasoline to oxygenate the gasoline to the maximum extent practical?

Response

MTBE concentrations in gasoline are currently limited to 15 percent (by volume). Assuming MTBE were used to oxygenate all gasoline to this level (except gasoline which is already blended with ethanol) a total of roughly 13 billion gal/yr of MTBE would be required in 1990 (16.2 billion gal/yr by the year 2005). U.S. MTBE consumption currently totals roughly 1.5 billion gal/yr, which means that the remaining 11.5 billion gal/yr (14.7 billion gallons in 2005) of MTBE would require new capacity.

MTBE is produced from the synthesis of methanol and iso-butylene. Methanol is made from natural gas via a steam reforming process. Isobutylene is produced both at refineries, and by the isomerization and/or dehydrogenation of normal and iso-butane, a product of refinery and NGL plants. Thus, not only would the construction of new MTBE plants be needed (including butane isomerization and dehydrogenation equipment), but additional methanol production capacity would be required as well. To fully meet the required MTBE demand, a total of 11.5 billion gal/yr of MTBE capacity (at a cost of roughly $11 billion) and 3.9 billion gal/yr of additional methanol production capacity (roughly $4 billion) would be required. With projected growth in gasoline demand, total MTBE requirements in the year 2005 would approach 16.2 billion gal/yr, thus adding another $4 billion to total infrastructure requirements.

Question 7

How much North American cultivated land and new infrastructure would be needed today, in 1995, 2000, and 2005 to produce enough ETBE to add to gasoline to oxygenate the gasoline to the maximum extent practical?

Response

EPA has not studied this question. However, the Department of Agriculture has supplied the following information to Senator Johnston in response to similar questions.

PREVIOUS QUESTION TO AND RESPONSE FROM USDA SUPPLIED AS A COURTESY TO THE COMMITTEE

Question

How much land would have to be cultivated to produce feedstock for ethanol if it became the sole alternative fuel for the President's Clean Fuels Program in 1995? 2000? 2005? What percentage increase in land under cultivation would this represent?

Response

A small change in total cultivated acres would be expected. Much of the land necessary for additional ethanol production would be land formerly planted in soybeans. Soybean acres would fall because the products associated with ethanol production (DDGS or corn gluten feed, meal, and oil) compete with soybean meal and oil. Additional ethanol byproducts would put downward pressure on soybean meal and oil prices causing farmers to switch from soybean to corn production. As a result of the switch from soybeans to corn coupled with the assumption that additional ethanol production is phased-in over time, there is a negligible change in total cultivated acres in 1995, an increase of about 2.5 million acres in 2000, and an increase of almost 3 million acres by 2005. Corn acres would be about 6 and 8 million acres higher in 2000 and 2005 while soybeans acres would fall by about 5 and 10 million acres in 2000 and 2005, respectively. Wheat acreage would increase by about 3 million acres while sorghum would increase by about 1 million acres.

In all years this increase in land under cultivation represents less than 1 percent of total land under cultivation.

PREVIOUS QUESTION TO AND RESPONSE FROM USDA SUPPLIED AS A COURTESY TO THE COMMITTEE

Question

If the EPA decided to mandate oxygenating all gasoline with 15-17 percent ethyl tertiary butyl ether (ETBE) which uses ethanol as a feedstock, to solve the clean air problem, what would your answers to question 1 be? What percentage increase in land under cultivation would this represent?

Response

A small change in cultivated acreage would be expected for the same reasons given in response to the earlier question. However, the magnitudes are slightly larger given the added ethanol needed. There would be a negligible change in total cultivated acres in 1995, an increase of about 3.0 million acres in 2000, and an increase of almost 3.3 million acres by 2005. Corn acres would be about 7 and 9 million acres higher in 2000 and 2005 while soybean acres would fall by about 6 and 13 million acres in 2000 and 2005, respectively. Wheat acreage would increase by about 4 million acres while sorghum would increase by about 1 million acres.

In 1995 the change would be negligible. In 2000 and 2005, the increase in land under cultivation represents slightly over 1 percent of total land under cultivation.

Question 8

Is it technologically and economically feasible to design automobiles and fueling infrastructures that significantly reduce refueling, running loss, hot soak and diurnal reactivity adjusted VOC emissions?

How much would it cost per new vehicle, and per gallon of new fuel sold over various phase-in periods?

Response

The answer to the initial question is yes. The President's proposal to Congress includes provisions that would control running losses and evaporative emissions through larger canister capacity and increased purge at a cost of roughly $10 per vehicle. Recovered fuel compensates for most of this cost, leaving a net cost of $3.80 per vehicle and an annual total cost of $60-68 million. The President's proposal also calls for Stage II refueling controls to be implemented in all moderate, serious and severe ozone non-attainment areas at an annualized cost of $120-150 million. Together, these two changes are expected to reduce VOC emissions from vehicles complying with current standards and operating on 9 RVP gasoline by 36 percent.

Question 9

Is it possible to adopt the Trans-Alaska oil pipeline facilities to "batch" transport methanol produced on the North Slope to Valdez and store it until loaded on tankers? How much would it cost? What would the cost of a parallel methanol pipeline be?

Response

Vast quantities of natural gas are co-produced with Alaskan oil and are currently reinjected into the oil reservoirs at significant cost, due to the fact that no market for the gas currently exists. This is done in part to maintain oil reservoir pressure for oil production and to conserve the gas resource for future use. At current reinjection rates this gas could be used to produce approximately 14 billion gallons of fuel methanol annually. The price at which such gas could be supplied to a methanol plant could be relatively low, particularly if no other markets are developed for this gas. Jensen Associates, Inc., estimated the price at $0.33/MMBtu.[1] Considering that the current cost of gas reinjection would be displaced, the price of the gas might be even lower.

Although the large reserve of low-cost natural gas makes the North Slope a potential methanol production site, difficulties associated with its Arctic climate make the economics less favorable than other potential methanol plant sites. Two alternative scenarios exist for producing methanol from Alaskan natural gas: either pipeline transport of natural gas to Valdez with methanol production at the port, or North Slope production of methanol with subsequent pipeline transport of the methanol. Of these two options the latter is probably more practical, since no Trans-Alaska gas pipeline currently exists. The cost of constructing a new gas pipeline would likely be prohibitive.

Even under the latter scenario, however, two major barriers to the use of North Slope gas exist: the high cost of building a methanol plant in a remote Arctic location and the potentially high cost of transporting methanol from icebound Prudhoe Bay to the lower-48 states. Two studies, one by DOE and one by Bechtel, have estimated the construction cost of a North Slope 10,000 tpd methanol plant to be $1.3-1.5 billion (compared to costs of $0.6-1.1 billion in other areas.)[2,3] These capital costs alone would contribute 18-21¢/gal to methanol production costs. Adding in an additional 9¢/gal for non-gas operating costs and assuming a natural gas price of $0.33/MMBtu yields a plant gate methanol price of 30-33¢/gal. This is within the range of plant gate methanol costs (25-35¢/gal) estimated for other world sites in EPA's special report.

The cost of transporting methanol from Alaska's North Slope could be prohibitive, if a new pipeline were to be built. Bechtel estimated transportation costs from the North Slope to California to be 52¢/gal, 48¢/gal of which would be due to the cost of constructing and operating a new Trans-Alaska methanol pipeline.[3] Transportation cost would be much lower, however, if spare capacity in the existing pipeline could be used.

Previous discussions with the Alaska Oil/Gas Conservation Commission and recent Oil & Gas Journal reports indicate that Alaskan oil production is projected to decline to 50 percent of present levels by 1997 if additional discoveries are not made, creating more than enough spare pipeline capacity to ship 14 billion gallons of methanol.[4-6] Unless new Alaskan oil fields are opened, batch shipping of methanol through the Trans-Alaska pipeline should be possible during the timeframe of the Administration's program. The cost of using this spare capacity would likely be low, since pipeline owners would be faced with either providing pipeline capacity at a price which would allow North Slope methanol to compete, or allowing spare pipeline capacity to remain idle. Thus, it is possible that methanol could be shipped through the Alaska pipeline at relatively low cost assuming no further oil discoveries. The operating cost of the pipeline is estimated at 2-3¢/gal although there is uncertainty about maintenance and upkeep cost. The 4¢/gal estimated by Bechtel for delivery from Valdez to Southern California yields a total transportation cost of 6-7¢/gal. Transportation to the Eastern Coast or Central states would be costlier. On average, North Slope methanol could be provided to the U.S. at a total transportation cost of roughly 8¢/gal, the figure used in the EPA special report.

In summary, if gas were available at $0.33/MMBtu and with spare Trans-Alaska pipeline capacity available, North Slope methanol could be supplied to U.S. port at a price of approximately 40¢/gal. At this price, while marginally cheaper methanol might be available from other sources, the North Slope could compete with other methanol production sites.

References

1. "Natural gas Supply, Demand, and Price," James T. Jensen, Jensen Associates, Inc., February 1989.

2. "Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector, Technical Report Two: Executive Summary--Methanol and LNG Production and Transportation Costs," Office of Policy, Planning and Analysis, U.S. DOE, May 1989.

3. "California Fuel Methanol Cost Study," prepared by Bechtel, Inc., for Chevron U.S.A., Inc., Amoco Oil Company, ARCO Products Company, California Energy Commission, Canadian Oxygenated Fuels Association, Electric Power Research Institute, Mobil Research and Development Corporation, South Coast Air Quality Management District, Texaco Refining and Marketing, Inc., Union Oil Company of California, January 1989.

4. Personal communication with Mr. Chat Chatterson, Alaska Oil/Gas Conservation Commission, May 8, 1989.

5. "No Quick Turnaround in Sight for Alaskan Oil Production Slide," Bob Williams, Oil & Gas Journal, September 25, 1989.

6. "Alaskan Oil Flow Outlook Dimmed by Tax Threat," Bob Williams, Oil & Gas Journal, October 6, 1989.

Question 10

How much would an "economy of scale" methanol plant cost if constructed on the North Slope? Trinidad? Venezuela? Nigeria? Saudi Arabia?

How much would operation and maintenance on those plants and facilities necessary to transport, store, and load methanol onto tankers costs?

Response

The large methanol demand which could be generated under the alternative fuels program would likely stimulate the construction of several large scale fuel methanol plants. These plants would be on the order of 10,000 tpd (or greater) capacity, roughly four times the size of the largest methanol plants being built today. Both Bechtel and DOE have examined the cost of constructing 10,000 tpd methanol plants in a variety of locations. Bechtel estimated total capital construction costs (including off-sites, engineering, and contingency) for the Trinidad, Saudi Arabia, and North Slope sites. DOE, in a more comprehensive analysis, estimated capital costs for four typical site categories. Site specific construction costs taken from each of the studies are shown in Table 1 below.

Table 1

	Total Cost (Million $)	
Location	DOE	Bechtel
Trinidad	588	985
Saudi Arabia	679-919	1088
North Slope	1322.8	1489
Nigeria	919.2	--
Venezuela	679-919	--

DOE estimates operation and maintenance costs for a 10,000 MTPD methanol plant located in the most accessible site category to be $66 million per year or roughly 6¢ per gallon of methanol. This is in agreement with Bechtel which estimates between $61 and $66 million per year for operation and maintenance costs. With respect to port facilities, Bechtel estimates investment costs to be $35 to $50 million, with an annual operating cost of approximately $20 million. Combined, operation, maintenance, and port facilities costs represent a small fraction of total investment costs for a 10,000 MTPD methanol plant.

Question 11

At what rates of production is flared or vented natural gas produced in all of the remote locations referred to in EPA's testimony? Given these rates of associated gas production, could each large methanol plant be supplied with enough feedstock to produce consistently at design capacity? For how many years could these plants operate at design levels based on estimates of proven reserves of associated gas for the various locations?

Response

Table 1 lists the annual unmarketed natural gas which is vented and flared in all of the remote locations referred to in EPA's analysis of methanol as an alternative fuel. Given the amount of annual unmarketed vented and flared natural gas, there is more than enough to feed large scale methanol plants to produce at capacity. In some countries, this gas is relatively concentrated, leading to the possibility of collection for a methanol plant. However, in other countries associated gas is widely dispersed and may not be as competitive as other sources of gas. To provide fuel for the clean fuels program, each large methanol plants (10,000 tpd) would produce roughly 1.1 billion gallons of methanol per year while consuming approximately 100 billion cubic feet of natural gas.

The United States Geological Survey (USGS) estimates of associated natural gas reserves are listed in Table 2. These estimates range from a low of 6 tcf in Trinidad to over 100 tcf in several countries. By comparison, over an assumed 20 year life, a 10,000 MTPD methanol plant would consume only 2 trillion cubic feet of natural gas. Thus, each country listed in Table 2 could support several 10,000 tpd methanol plants with proven associated gas reserves.

TABLE 1

Region Country	Annual Unmarketed Natural Gas (bcf) and Methanol Potential (billion gal/yr): Vented, Flared* (bcf)	Methanol Equivalent** (bil gal/yr)	Reinjected* (bcf)	Methanol Equivalent** (bil gal/yr)	Total Natural Gas Reserves (tcf) and Methanol Potential (billion gals): Proved Reserves* (tcf)	Methanol Equivalent** (bil gals)
NORTH AMERICA						
Canada	88		497		98.0	
México	69		NA		76.5	
United States	98		1,838		187.2	
Total	255	3	2,335	24	361.7	3,747
CENTRAL AND SOUTH AMERICA						
Argentina	6		47		23.6	
Bolivia	4		59		5.0	
Brazil	33		36		3.6	
Chile	0		112		NA	
Colombia	18		14		3.6	
Trinidad and Tobago	108		0		10.4	
Venezuela	90		438		95.0	
Other	50		5		NA	
Total	309	3	711	7	150.1	1,555
WESTERN EUROPE						
France	0		0		NA	
Germany, West	0		0		6.4	
Italy	0		0		10.2	
Netherlands	0		0		64.1	
Norway	6		141		105.9	
United Kingdom	77		113		22.0	
Other	9		24		NA	
Total	92	1	278	3	218.1	2,260
EASTERN EUROPE AND U.S.S.R.						
Germany, East	0		0		NA	
Hungary	0		0		NA	
Poland	0		0		NA	
Romania	0		0		NA	
U.S.S.R.	350		NA		1,450.0	
Other	0		0		NA	
Total	350	4	0	0	1,479.3	15,326
MIDDLE EAST						
Bahrain	0		65		6.9	
Iran	175		430		489.4	
Kuwait	23		2		42.6	
Oman	10		50		9.5	
Qatar	0		0		156.7	
Saudi Arabia	98		67		146.1	
United Arab Emirates	175		56		203.5	
Other	246		0		NA	
Total	727	8	670	7	1,084.1	11,231
AFRICA						
Algeria	275		1,570		105.9	
Egypt	33		0		10.2	
Libya	25		190		25.7	
Nigeria	445		81		84.0	
Other	171		61		NA	
Total	949	10	1,902	20	248.7	2,577
FAR EAST AND OCEANIA						
Afghanistan	0		0		NA	
Australia	0		0		18.6	
Brunei	10		0		7.0	
China	NA		NA		30.7	
India	100		0		17.6	
Indonesia	108		225		73.0	
Japan	0		0		NA	
Malaysia	75		0		52.2	
New Zealand	0		30		5.2	
Pakistan	0		0		22.4	
Other	0		0		NA	
Total	293	3	255	3	233.5	2,647
WORLD TOTAL	**2,975**	**31**	**6,151**	**64**	**3,797.6**	**39,343**

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* From Energy Information Administration

** Assuming a 65% natural gas-to-methanol conversion efficiency

Table 2

Country	USGS Estimated Associated Gas Reserves (TCF)
Iran	279
USSR	151
UAE	128
Nigeria	52
Indonesia	43
Algeria	33
Venezuela	33
Iraq	31
United Kingdom	22
Malaysia	18
India	16
Libya	15
Trinidad	6
Total	826

Question 12

Mr. Rosenberg testified that "most of the methanol with the exception of what is produced in Alaska, if any, will be imported just as most of the incremental gasoline that is going to meet our increased demand will be imported." Why will most additional gasoline come from imports.

Response

Mr. Rosenberg's statement was based on an extrapolation of two current trends. One, oil refinery capacity in the U.S. has decreased dramatically since 1980. Despite substantial increases in U.S. gasoline demand over the past four years, to the point where gasoline refinery margins are at historic highs due to industry-wide operation at peak capacity, no new refineries have been built, nor announcement of new refinery plans made. Some capacity additions have been made which have increased gasoline production capacity, but these have been quite small. Two, foreign refinery capacity has been increasing, particularly in those countries producing crude oil for export. The result has been that imports of finished gasoline to U.S. have increased over the last decade. These historic trends and their projected continuance are supported in DOE's recent "Annual Outlook for Oil and Gas, 1989."

Question 13

Will the President's or any other clean air proposal effectively inhibit the ability of new domestic refineries to produce gasoline? Will any other federal or state proposals do so?

Response

The clean, alternative fuels initiative proposed by the President (representing about 7 percent of motor vehicle fuel sales by 2010) would not have any significant impact on the existing U.S. refinery system. The program, of course, may reduce the amount of gasoline that would otherwise have been consumed by gasoline vehicles, but this potentially foregone demand is only about one-third of the overall growth projected for gasoline demand in the 1995 to 2010 timeframe. Thus, not only is it unlikely that refineries be forced to close, but additional refinery capacity will likely be needed.

Current gasoline sales are approximately 95 billion gallons per year. EPA's highway fuel consumption model projects that absent any neat fuels program (or more stringent fuel economy standards), total gasoline sales will increase to 99 billion gallons in 1995 and 129 billion gallons in 2010 (assuming oil prices in the range of $15-25 per barrel in 1988 dollars). This represents an annual increase in gasoline consumption of between 1.5 and 2 percent per year, due primarily to projected increases in vehicle miles traveled, consistent with historical trends.

The proposed clean fuels program involves annual sales of 1 million clean fuel vehicles. These annual vehicle sales may displace just under one-half percent of total gasoline demand in each year after 1996, and the total amount of gasoline that may be displaced will grow by an equal amount each year thereafter. Thus, if any gasoline is displaced by the neat fuels program, it will only be about one-third of the growth otherwise projected for gasoline sales.

Even with the neat fuels program described above, annual gasoline sales are projected to increase from 95 billion gallons today to 98 billion gallons in 1995 and to 108 billion gallons in 2010.

Question 14

The President's Clean Fuels Program would force auto manufacturers to sell 500,000 clean fuel vehicles in 1995 in the 9 urban non-attainment areas, and increase sales to 1 million per year for the years 1997-2004. Is the principal reason for this approach to create an alternative fuels market? Is this allowing the marketplace to work, or creating an artificial market?

Response

The principal reason for this approach is to create an alternative fuels market. Most who have studied the issue of new automotive fuels have concluded that it involves a classic chicken-or-egg dilemma: automakers will not invest in newer cars without the certainty of convenient fuel availability, and the energy industry will not invest in fuel production and distribution infrastructure until the vehicles are in the fleet. The President's proposal resolves the chicken-or-egg dilemma by ensuring that vehicles and fuels will be introduced concurrently.

The President's proposal requires that a certain fraction of new vehicles in our dirtiest metropolitan areas be cleaner than the rest of the vehicles entering the fleet, in order to help these areas achieve healthy air. Market incentives such as trading and banking are included in order to introduce some flexibility and efficiency into the program. The program is designed to be fuel neutral. Our program redirects the marketplace to bring about the necessary vehicle emissions reductions in our dirtiest metropolitan areas. This is a government induced market to meet a public policy clean air goal.

Question 15

Retail service stations in those non-attainment areas must sell at least one type of clean fuel if their monthly sales volume is over 50,000 gallons per month, on average. In addition, the EPA Administrator could require that clean fuels be sold in major transportation corridors outside the non-attainment areas. Is this a market approach? Again, why did the Administration take such a heavy handed approach?

Response

Convenient fuel availability is a critical part of the chicken-or-egg dilemma, i.e., no clean fuels program could possibly succeed without the certainty of convenient and economically competitive fuel availability. We tried to minimize the impact of the initial requirement by limiting its applicability to high-volume service stations. It is important to note that there is a precedent for the federal government requiring a reformulated transportation fuel -- the introduction of unleaded gasoline in 1975. EPA promulgated regulations to ensure the general availability of unleaded gasoline compatible with the 1975 catalytic converter emission control systems that were being utilized by the automotive manufacturers. These regulations applied to high-volume stations as well as certain rural stations. Despite the concerns of many in the gasoline refining and marketing industry, the transition to unleaded gasoline proceeded smoothly and has been a model for other countries. The clean, alternative fuels program would affect far fewer service stations than the unleaded gasoline requirement because it is focused only on our most polluted urban areas. However, potentially new and multiple clean fuels may have to be made available.

Question 16A

The recent EPA methanol study states that flexible fuel vehicles are projected to emit at least 30 percent less volatile organic compounds "(VOCs)" than gasoline powered autos. Yet the Office of Technology Assessment report "Catching our Breath", states (at P. 147) that blends of methanol and gasoline (M85) could easily be several times more expensive per ton of VOC's reduced than any other measure [OTA has] considered." OTA then states that "the costs are extremely sensitive to prices assumed for gasoline and methanol".

Doesn't this make methanol potentially very risky and expensive?

Response

It must be emphasized that the President's proposal does not favor methanol over any other alternative fuel; reformulated gasoline will have the opportunity to meet our emissions performance standards. Those fuels that "win out" will be those that with comparative advantage will be most cost effective. Accordingly, if methanol turns out to be "risky and expensive," it is unlikely to be the fuel of choice. Competitive pressures will force automotive manufacturers to choose the most cost-effective fuels, i.e., if manufacturer A markets a vehicle that has a lower operating cost than manufacturer B, then manufacturer B will lose market share requiring it to reduce its vehicle price or buy vehicle credits from manufacturer A.

Question 16B

Would you comment on OTA's conclusion that the cheapest method to reduce VOC emissions is lowering gasoline volatility at $120 to $750 per ton; while the most expensive is methanol, at $8,700 to $51,000 per ton of VOC reduction?

Response

We disagree with OTA's methanol cost effectiveness values. It is relevant to note that OTA's assumptions regarding VOC emission reductions with methanol of 30 percent in the near term and 90 percent in the long term (see page 189 of its report) are very consistent with our projections. But we strongly disagree with OTA's economic assumptions, which were the result of a very cursory analysis. They assumed a methanol production cost of 40 to 60 cents per gallon, while our midpoint estimate is 35 cents per gallon (Department of Energy projections for large, advanced scheme plants are in the range of 35 to 40 cents). OTA completely ignored recent work that assumes the economies of scale in methanol fuel production that would be available in a high-demand program. OTA also used very high distribution and service station markup costs that we believe are not appropriate for a clean fuels program like that contained in the Bush bill that would involve economies of scale in fuel distribution. It is our understanding that OTA is now preparing a more detailed analysis of methanol fuel economics.

Question 17A

If Congress mandated the improvements in "CAFE" standards, lower gasoline vapor pressure and aromatic content, and use of compressed natural gas in vehicles such as urban mass transit, fleets with 10 or more, heavy trucks, and off-the-road vehicles like bulldozers:

What kind of ambient air quality improvement could we expect?

Response

It is not possible to project the total air quality improvements of such a package of proposals without specifying specific control levels. What can be said about these proposals is as follows. Increases in fuel economy would proportionally decrease carbon dioxide emissions, could decrease oxides of nitrogen emissions somewhat, but would likely not affect hydrocarbon or carbon monoxide or toxics emissions. Lowering gasoline vapor pressure, or volatility, will reduce evaporative hydrocarbon emissions (but will not affect other emissions). For example, reducing gasoline volatility from the current standard, based on 10.5 pounds per square inch (psi) fuel in Class C areas, to a lower standard of 9 psi would reduce vehicle hydrocarbon emissions by about 20 percent, or overall urban hydrocarbon emissions by about 8 percent. EPA has a proposal out now to reduce volatility to 9 psi. The primary benefit of reducing gasoline aromatic content (benzene, toluene, xylene) would be to reduce toxic air emissions, particularly those of benzene. Reducing xylene levels would also reduce hydrocarbons to some degree. The use of compressed natural gas would likely reduce hydrocarbon, carbon monoxide, and air toxics emissions from vehicles that would otherwise use gasoline and would likely reduce particulate and toxic emissions from vehicles that would otherwise use diesel fuel.

Question 17B

How much would it cost per ton of "VOC" emissions?

Response

Fuel economy improvements and aromatic reductions would not likely reduce VOC emissions much or at all, and though cost effectiveness values are not available due to small impacts they would be very high. Lowering gasoline volatility is estimated to be very cost effective, at a cost of approximately $100 to $200 per ton. We have not yet calculated the VOC cost effectiveness of compressed natural gas usage, as with all alternative fuels the cost effectiveness will be dependent upon fuel cost relative to that of gasoline.

Question 18

Researchers report that pure methanol vehicles emit high levels of formaldehyde, especially after the test vehicles have been in use for a while. Formaldehyde forms ozone in the presence of sunlight, is a probable human carcinogen at concentrations of 3-15 parts per million in the air, and is an eye and nasal irritant for 95 percent of the population at 0.1 ppm.

A) What are the average, 1 day and 3 day peak ambient air concentrations of formaldehyde? All aldehydes?

B) Wouldn't formaldehyde be irritating and possibly unhealthy to people stuck in traffic jams, tunnels, parking garages? What would the ambient air formaldehyde concentration be in these cases?

C) Isn't formaldehyde converted to ozone and smog in the presence of sunlight just like other VOC emissions like gasoline vapors? How much reactivity adjusted VOCs would be produced from formaldehyde emitted from an M100 vehicle versus VOC emissions from a gasoline vehicle that result in indirect formaldehyde formation?

D) What are you gaining if you reduce indirect formaldehyde produced by evaporative gasoline emissions and allow direct formaldehyde emissions to increase by a similar amount?

Responses

With regard to these opening remarks, the following clarifications are offered. First, no M100 vehicles other than several experimental vehicles have been built and placed in use. M85 vehicles have been in use and some emit formaldehyde levels roughly a few times higher than from gasoline vehicles. The difference is within an order of magnitude. Relatively high formaldehyde from the M85 vehicles that have been in use for a while probably reflects their crude, first-attempt-ever design rather than any inherent effects of in-use service per se. We expect that formaldehyde emissions from in-use dedicated M100 cars will be lower than from M85 flexible fuel cars because of the ability to optimize the emissions control systems on dedicated M100 cars for formaldehyde. Second, EPA assumes that formaldehyde, like other carcinogens, is carcinogenic at any concentration, with the risk proportional to the concentration. Third, irritation of the eyes and upper airway may occur at concentrations as low as 0.1 ppm, but any irritation at this concentration should be minor and reversible for most people. However, susceptible subpopulations have not been defined.

A) The annual average urban concentration of formaldehyde is roughly 2.5 ppb. The annual average urban concentration of all aldehydes for which monitoring data are available (formaldehyde, acetaldehyde, and acrolein) is roughly 3.9 ppb. These estimates are based on 24 hour samples taken every 12 days at 19 sites in 17 urban areas during the 1988 fiscal year. The average of the highest 24 hour concentrations seen at each of these 19 sites for formaldehyde, acetaldehyde, and acrolein are 6.4, 3.6, and 0.2 ppb, respectively. Three day peak concentrations cannot be provided since 3 day consecutive monitoring data for the aldehydes are not available.

Photochemical modeling of California's South Coast Air Basin showed that the use of methanol vehicles would not increase formaldehyde levels markedly, and could lead to a decrease, depending on the formaldehyde emission rate assumed.

B) Formaldehyde is emitted from gasoline as well as methanol vehicles. EPA has estimated formaldehyde exposure from vehicle emissions in the following scenarios: street canyon (urban street surrounded by tall buildings), roadway tunnel, expressway, and public and private garages. These scenarios were chosen because they are heavily impacted by motor vehicles and are expected to provide an indication of worst-case short-term exposures. The estimates showed that, for both methanol and gasoline vehicles, the scenarios which could potentially result in noticeable health effects to the general public would be situations in which vehicles are idled in either public parking or private garages. Predicted formaldehyde concentrations in these scenarios range from 0.02 to 5 ppm for gasoline vehicles and 0.08 to 6.7 ppm for methanol vehicles. Also, it has been noted that the corresponding CO concentrations could exceed the ACGIH 15 minute Short Term Exposure Limit (STEL) of 360 ppm. Thus, the potential for adverse exposure to toxic pollutants in garages is not unique to methanol vehicles nor to formaldehyde.

C) Yes, formaldehyde is converted to ozone in the presence of sunlight just like gasoline vapors and other VOC emissions. Based on modeling results for a number of cities, EPA in 1988 estimated that, on an equal gram per mile basis, formaldehyde forms 220 percent of the ozone formed by typical HC from gasoline vehicles. EPA estimates that an optimized M100 vehicle would emit 0.015 g/mile formaldehyde or 0.033 g/mile VOC-equivalent emissions (0.015 x 2.2). Gasoline vehicles in the year 2005 designed to meet the current standards are estimated to emit 1.73 g/mile NMHC. Gasoline vehicles under the standards proposed by President Bush are assumed to emit 0.94 g/mile NMHC. The 0.033 g/mile number is roughly 2% and 4% respectively of the 1.73 and 0.94 g/mile numbers. Thus, the reactivity of the formaldehyde emissions from an M100 vehicle represents 2-4% of the reactivity of the NMHC emissions from these two types of gasoline vehicles.

D) Even if M100 vehicles do not significantly affect ambient formaldehyde levels, significant ozone and other toxic benefits are still predicted.

Senator McClure Questions

Question 1

If the President's Clean Fuels Program were fully implemented, what would be the percentage incremental benefits attributed to the alternative fuels program, if M85 were the fuel of choice? If M100 were the fuel of choice?

Response

If the President's Clean Fuels Program were fully implemented, using only M85 vehicles beginning in 1995, the percentage incremental VOC reduction attributed to the alternative fuels program is estimated to be 0.5 percent of 1987-level emissions in the year 2005. If M85 vehicles are used from 1995 through 1999 and M100 vehicles from 2000 to 2005, the percentage incremental VOC reduction attributed to the alternative fuels program is estimated to be 0.9 percent in the year 2005, 1.4 percent in 2010, and 1.7 percent in 2020. If consumer preference for M100 vehicles resulted in all sales after 2000 being M100, the benefits would be 2.7, 5.0, and 7.0 percent in 2005, 2010, and 2020, respectively.

All of the percent VOC reductions listed above are relative to the 1987 VOC inventory. If these reductions were expressed for the yesr in which they would occur, they would be somewhat larger.

Question 2

In a 1987 report to the Vice President's Task Force on Alternative Fuels, EPA estimated the reductions in ozone levels that would occur in New York, Washington, D.C. and Los Angeles by introducing current and advance technology methanol vehicles. EPA concluded that replacing 15 percent of vehicle miles traveled in these three cities would reduce ozone levels by about 1 percent; replacing a quarter of all VMT would reduce ozone levels by a maximum of 1.7 percent. So-called "advanced methanol" technology was projected to achieve reductions of 3 to 4.5 percent by the year 2000. Do you agree with this assessment? If not, why not?

Response

EPA has since refined this earlier assessment. In the 1987 report, the methanol scenarios assumed complete replacement of gasoline fleet vehicles. This assumption is not carried over to the September 1989 assessment. In addition, the year 2000 advanced technology scenario in the 1987 report assumes replacement of gasoline vehicles with M85 vehicles from 1991-1995 and advanced technology M100 vehicles from 1995-2000. This is no longer considered a realistic schedule. The September 1989 assessment is based on the schedule proposed by the President. Also, the emission factors for the gasoline and methanol vehicles have been refined since the 1987 report.

Question 3

In September 1989, EPA released its latest assessment of of the air quality impacts of methanol use. The agency concluded that if the vehicles under President Bush's clean air proposal were dedicated to M100 after 1999 ozone levels in the year 2005 would be reduced by an average of 1.5 percent in nine of the nation's more polluted cities and the maximum benefit by the year 2015 would be 3.3 percent. Do you agree with this assessment? If not, why not?

Response

Please note that the 1.5 and 3.3 percent values given in the September 1989 special report on methanol are VOC reductions, not reductions in ambient ozone levels. Page 55 of the special report states this.

The estimates in the special report on methanol were made in June and July 1989, using approximate techniques and assumptions. A more detailed analyses was prepared subsequently, and was provided to House and Senate offices on September 15 (Ozone Nonattainment Analysis - A Comparison of Bills, Interim Report, US EPA Office of Air and Radiation). This more detailed analysis has been used to answer Question 1, on M85 versus M100 benefits. EPA regrets that delays in finalization and release of the special report resulted in its publication so close in time to the more detailed assessment, and that EPA did not explain the difference at the time.

The more detailed analysis accounts for several factors that had not been included in the June/July version. For example, the more detailed analysis recognizes that 1,000,000 vehicles will not represent a fixed 30% percent of sales due to growth in total vehicle sales. This is the most important difference.

Another important distinction is that the quoted benefits from the special report are expressed as a percentage of 2005 or 2015 VOC. The September 15 results are expressed as a percentage of 1987 VOC, for consistency with the reported reductions for other controls such as CTG's and tailpipe standards.

Question 4

A July 1989 report by the Office of Technology Assessment estimates the cost of removing hydrocarbons from the ambient air by the use of methanol vehicles is $30,000 per ton. This cost compares to $1,000 to $5,000 per ton for other technologies such as limiting gasoline volatility ($500 per ton), capturing vapors with special fuel pumps at filling stations ($1,000 per ton), or strengthening inspection and maintenance programs ($4,000 per ton). According to OTA, the most expensive method is replacement of gasoline with methanol, at $8,700 to $51,000 per ton of reductions. Do you agree with these estimates? If no, why not?

Response

No, we strongly disagree with OTA's methanol cost effectiveness estimates. Their numbers were the result of a very cursory analysis. While OTA used emissions reductions very similar to our projections, its methanol cost numbers are very high. They assumed a methanol production cost of 40 to 60 cents per gallon, while our midpoint estimate is 35 cents per gallon (DOE projections for large, advanced scheme plants are in the 35 to 40 cent range). OTA completely ignored recent work that assumed the economies of scale in methanol fuel production that would be available in a high-demand program. OTA also used very high distribution and service station markup costs that are not appropriate for a clean fuels program like that contained in the Bush bill that would involve economies of scale in fuel distribution. It is our understanding that OTA is now preparing a more detailed analysis of methanol fuel economics.

Question 5a

What are the most likely sources of methanol? Would you agree with the Department of Energy's assessment that the principle supplier of methanol will be Argentina, Chile, North Africa, and the Middle East?

Response

In the near term, methanol fuel will be produced where sufficient low cost natural gas is available to support a large scale production facility and where the political/economic climate is stable, involving limited risk to those who invest large amounts of capital in such plants. As shown in Table 1, according to DOE worldwide estimates, the volume of natural gas which is vented and flared annually (gas for which no economic market currently exists) is roughly 3 trillion cubic feet (tcf). More than twice this volume of gas is currently being reinjected into oil reservoirs. In some countries, this gas is relatively concentrated, leading to the possibility of collection for a methanol plant. However, in other countries associated gas is widely dispersed and may not be as competitive as other sources of gas. Combined, this unmarketed natural gas could be used to supply 95 billion gallons of methanol per year, six to seven times the stabilized methanol demand under the proposed alternative fuel program. Roughly 20 percent of this unmarketed gas is produced in the United States, the majority from the North Slope of Alaska. Approximately 30 percent is produced in Africa, 10 percent in South America, and 6 percent in the Far East. Only about 15 percent of this gas is produced in the Middle East. Possible production sites include Canada, Australia, Indonesia, Africa, Trinidad, South America, and the Persian Gulf.

Generally, there is a similarity between those countries with large amounts of associated gas and those listed in your question. However, notable absences from DOE's list are Nigeria, Venezuela (already building two methanol plants), and Indonesia, all of which currently produce and reinject, vent or flare enough natural gas for at least one, and up to five, very large multi-train fuel methanol plants.

In the long term, much more than enough proven gas reserves exist to supply methanol for the proposed clean fuel initiative for many years to come. Proven natural gas reserves total 3,800 tcf, more than two thousand times the annual amount required to supply methanol for the alternative fuel initiative. The natural gas supply is more geographically diverse than the world oil supply.

It is EPA's belief that U.S. energy security would be improved by using a fuel which is made from natural gas since: 1) gas reserves are distributed more evenly throughout the world, 2) a number of non-OPEC countries have sufficient unused gas reserves which are large enough to support a fuel methanol plant, 3) large quantities of gas are available in the Alaska North Slope and Canada, and 4) even with a reliance on foreign sources, having a viable alternative fuel based on a raw material other than crude oil would put downward pressure on petroleum prices.

TABLE 1

Region / Country	Annual Unmarketed Natural Gas (bcf) and Methanol Potential (billion gal/yr)				Total Natural Gas Reserves (tcf) and Methanol Potential (billion gals)	
	Vented, Flared* (bcf)	Methanol Equivalent** (bil gal/yr)	Reinjected* (bcf)	Methanol Equivalent** (bil gal/yr)	Proved Reserves* (tcf)	Methanol Equivalent** (bil gals)
NORTH AMERICA						
Canada	88		497		98.0	
Mexico	69		NA		76.5	
United States	98		1,838		187.2	
Total	255	3	2,335	24	361.7	3,747
CENTRAL AND SOUTH AMERICA						
Argentina	8		47		23.6	
Bolivia	4		59		5.0	
Brazil	33		36		3.6	
Chile	0		112		NA	
Colombia	18		14		3.6	
Trinidad and Tobago	100		0		10.4	
Venezuela	90		438		95.0	
Other	50		5		NA	
Total	309	3	711	7	150.1	1,555
WESTERN EUROPE						
France	0		0		NA	
Germany, West	0		0		6.4	
Italy	0		0		10.2	
Netherlands	0		0		64.1	
Norway	6		141		105.9	
United Kingdom	77		113		22.0	
Other	9		24		NA	
Total	92	1	278	3	218.1	2,260
EASTERN EUROPE AND U.S.S.R.						
Germany, East	0		0		NA	
Hungary	0		0		NA	
Poland	0		0		NA	
Romania	0		0		NA	
U.S.S.R.	390		NA		1,450.0	
Other	0		0		NA	
Total	390	4	0	0	1,479.3	15,326
MIDDLE EAST						
Bahrain	0		65		6.9	
Iran	175		430		489.4	
Kuwait	23		2		42.6	
Oman	10		50		9.5	
Qatar	0		0		156.7	
Saudi Arabia	98		67		146.1	
United Arab Emirates	175		56		203.5	
Other	246		0		NA	
Total	727	8	670	7	1,084.1	11,231
AFRICA						
Algeria	275		1,570		105.9	
Egypt	33		0		10.2	
Libya	25		190		25.7	
Nigeria	445		81		84.0	
Other	171		61		NA	
Total	949	10	1,902	20	248.7	2,577
FAR EAST AND OCEANIA						
Afghanistan	0		0		NA	
Australia	0		0		18.6	
Brunei	10		0		7.0	
China	NA		NA		30.7	
India	100		0		17.6	
Indonesia	108		225		73.0	
Japan	0		0		NA	
Malaysia	75		0		52.2	
New Zealand	0		30		5.2	
Pakistan	0		0		22.4	
Other	0		0		NA	
Total	293	3	255	3	255.5	2,647
WORLD TOTAL	**2,978**	**31**	**6,151**	**64**	**3,797.6**	**39,343**

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* From Energy Information Administration

** Assuming a 65% natural gas-to-methanol conversion efficiency

Questions 5b & 5d

Will the reliance of the United States on methanol as a transportation fuel add or detract from our national energy security?

If we become dependent on methanol as a transportation fuel, does the possibility exist that methanol prices will either be determined by international petroleum product prices or by a cartel similar to OPEC, if not OPEC itself?

Responses

In addition of methanol to the fuel market would provide a second transportation fuel, made from natural gas rather than oil. The competitive influence that the presence of methanol could have on the market would be to exert a restraining force on potential gasoline price increases.

The diversity of the world natural gas supply may serve to enhance national energy security. The methanol plants required for this program are likely to be built in locations with large supplies of remote natural gas for which there is no other competitive market. Such locations are numerous and include Alaska, Canada, Australia, Indonesia, Africa, Trinidad, South America, and the Persian Gulf. Due to the diversity of countries producing methanol, it appears much less likely that methanol prices would be determined by a cartel similar to OPEC. Interestingly, only about 15 percent of the lowest cost gas (i.e., that associated with oil production) is located in the Middle East. In the absence of fuel alternatives, consumers would remain dependent on foreign oil producers (OPEC, etc.).

Question 5c

Crude oil and gasoline are fungible products. Can this be said for methanol?

Response

Fungibility is the ability to mix two products, as in the case of shipments through a pipeline, without having an effect on the products. Currently, gasoline may or may not be fungible, depending on whether or not it meets certain specifications set by pipelines. Crude oil is usually not fungible unless it comes from the same field, because of the large chemical differences which exist between the various types of crude oil (for example, light, heavy, low sulfur, high sulfur, etc.).

With regard to methanol, methanol production yields virtually one compound, with small quantities of water, higher alcohols, etc. Exact specifications for fuel grade methanol (M85 or M100) have not yet been determined, but once they are, it is unlikely that pipelines would place any additional specifications on the methanol fuel since it is so uniform a product. Thus, for pipelines and other distribution systems, methanol should be a very fungible product.

Question 6

What would be the capital investment (in production facilities, vehicles, refueling outlets, etc.) required to implement the President's Clean Fuels Program,

a. if methanol were the fuel of choice?

b. if natural gas were the fuel of choice?

c. if reformulated gasoline were the fuel of choice?

d. and for other feasible alternative fuels?

Response

We have committed to a series of reports analyzing the environmental and economic impacts of each of the candidate clean alternative fuels: methanol, ethanol, compressed natural gas, liquefied petroleum gas, electricity, and reformulated gasoline. At this time only the methanol report has been completed. All of the capital costs associated with methanol fuel production (plants), distribution (tankers, terminals, and trucks), and sale (service station modifications) were accounted for in our analysis of the per gallon cost of methanol. We believe this is the most appropriate way to account for capital costs since this is precisely how money is raised for capital investments. Nevertheless, we recognize that projecting the "total capital investment" necessary to implement the clean alternative fuels program is of interest. Accordingly, we are now in the process of calculating the "total capital investment" for the methanol fuel scenario. We will likewise perform similar analyses for the other candidate clean alternative fuels. We believe the Department of Energy has much relevant information on this matter.

Question 7

From the standpoint of overall energy efficiency, what is the comparable energy efficiency of an automobile which uses --

a. Gasoline as a fuel?

b. Methanol derived from natural gas?

c. Methanol derived from coal?

d. Compressed natural gas?

e. Gasohol?

f. Reformulated gasoline?

g. Other alternative fuels?

Response

As stated above, we are in the process of preparing detailed reports on the environmental and economic effects of the various candidate clean alternative fuels. The only report that has been completed at this time is the methanol report. With respect to vehicle efficiency, we project that methanol flexible fuel vehicles would be approximately 5 percent more energy efficient than a comparable gasoline vehicle. Dedicated, optimized methanol vehicles are projected to be 30 percent more energy efficient.

If by "overall energy efficiency" the question concerns overall energy utilization from raw material to mile travelled, then one surrogate for this that we have investigated is life cycle carbon dioxide (CO_2) emissions. Using conventional gasoline from crude oil as a baseline, our preliminary analysis suggests that a methanol flexible fuel vehicle using methanol produced from a new natural gas field would emit slightly more life-cycle CO_2, while a dedicated methanol vehicle using methanol from a new field would emit slightly less life-cycle CO_2 emissions. Of course, if either type of methanol vehicle used methanol produced from natural gas that would have otherwise been vented or flared, the net life-cycle CO_2 emissions would be much less than with gasoline. If coal were used as a methanol feedstock, and CO_2 emissions at the production plant were not controlled, life-cycle CO_2 emissions would be much higher. If biomass were used as a methanol feedstock, life-cycle CO_2 emissions would be much lower.

We expect to perform similar analyses for the other candidate clean alternative fuels.

Question 8a

The Administration emphasizes that the President's Clean Fuel Program is limited to nine cities, principally in major transportation corridors. Consequently, other States may find the program politically attractive.

What would be the recommendation regarding a wider use of alternative fuels such as methanol, than is envisioned by the Administration's program?

Response

The Agency does not have a specific recommendation. Other areas could decide whether to join the clean alternative fuels program on their own. If the clean alternative fuels program is a success, we would expect other cities to seriously consider joining the program as one way to meet their annual VOC emissions reduction requirements.

Question 8b

What other alternative fuels than methanol are currently available that the Administration supports?

Response

The Agency supports the consideration and use of all clean fuels that provide vehicle emission reductions, including, but not limited to ethanol, methanol, compressed natural gas, liquefied petroleum gas, electricity, and reformulated gasoline. We must emphasize that the President's proposal is fuel neutral and does not favor any one fuel over any other.

Question 8c

Would methanol be practical as alternative fuel in "cold", northern cities? Is there not a problem with starting methanol cars under cold, winter conditions?

Response

If methanol were the fuel of choice, we would expect the vehicles in the early years of the program to be methanol flexible fuel vehicles which would operate on M85 (85 percent methanol, 15 percent gasoline). These vehicles meet all cold-start specifications set by the auto manufacturers, so they would perform very well in northern cities.

A current gasoline engine will not start on pure methanol (M100) below about 50°F without modifications. There are many strategies now under investigation to permit good cold-starting with M100 at low temperatures. By providing adequate leadtime to auto companies, as the President's proposal does, we are confident this engineering problem can be solved.

Question 9

What are the public health and safety risks associated with the wide-spread use of methanol? For example, what are the hazards of spilling methanol on your hands when filling your car's gas tank? We all have experienced this problem at one time or another.

Response

Methanol is not generally considered a toxic pollutant at levels likely to be inhaled from use as a motor vehicle fuel. Methanol has not been studied using classical chronic carcinogenic bioassays and thus its carcinogenic potency is unknown. However, results from some other types of cancer studies with methanol do not raise concerns. On the other hand, benzene in gasoline is a known carcinogen, and the gasoline vapor itself is a possible carcinogen. The use of methanol is anticipated to result in reductions in overall cancer incidence relative to gasoline vehicles.

With regard to skin absorption of methanol, methanol is not as good a solvent for oils and greases as gasoline, so the frequency with which it is used for degreasing or cleaning hands is likely to be less than with gasoline even without educational efforts to avoid it. Splashes on the hand when filling a car's gas tank should evaporate quickly, and as a result, are not of long enough duration to be of concern. Furthermore, skin absorption of methanol is slow enough that momentary contact is not a significant concern. For reference, the added body burden of methanol from total immersion of a hand in methanol for one minute is equivalent to that obtained from drinking roughly four cans of a diet beverage. (Diet beverages contain the artificial sweetener aspartame, 10% of which becomes methanol in the body). Only if methanol is maintained in contact with the skin such as with methanol soaked clothing are concerns likely to arise. Education will be necessary to cover cases with potential, prolonged exposure.

Neat methanol has no taste, color, or detectable odor and, as a result, may be more likely to be ingested than gasoline. After methanol is ingested, there is typically a 12-24 hour delay before symptoms such as visual disturbance appear. This delay adds a special danger to methanol ingestion, as failure to obtain prompt treatment can result in permanent blindness, neurologic impairment, or death. There is also an enormous variability in susceptibility for methanol exposure. As little as 2 teaspoons of methanol have resulted in death, while 5 to 30 times this level is a normal lethal range if treatment is not given. Small amounts of gasoline aspirated into the lungs can also result in death, but this occurrence is statistically rare.

The main causes of motor fuel ingestion are siphoning by adults and ingestion by children of fuels stored in containers around the home. The vast majority of these occurrences can be avoided by preventing siphoning from vehicles through the use of inexpensive anti-siphoning devices. In addition, additives to neat methanol can be used to give it an identifiable odor, taste, and/or color in order to reduce the chance of accidental ingestion.

With regard to fire safety of methanol, there are two main advantages and two main disadvantages. The advantages, along with the possibility for mitigating the disadvantages, cause the fire safety risks of methanol to be lower than for gasoline. Methanol's low volatility, relatively high flammability limit, and low vapor density cause it to be much less likely to ignite in a open area resulting from a spill of fuel or release of vapor. In addition, once it does ignite, methanol's low heat of combustion and high heat of vaporization cause it to burn much slower and less violently, releasing heat at roughly one-fifth the rate of gasoline. However, these same combustion properties cause methanol to be in the flammable range inside fuel storage tanks under normal ambient temperatures (45-108°F), while gasoline is virtually always too rich to ignite. Fortunately, precautions can be taken to prevent either flammable vapor/air mixtures from forming in storage tanks or to prevent ignition sources from entering the tanks, thereby mitigating any additional risk. The other disadvantage of methanol is that due to the lack of any large carbonaceous particles in its products of combustion, pure methanol burns with a light blue flame which is essentially invisible to the human eye in bright daylight. This can represent a serious safety concern for fire identification and its accompanying warnings. Fortunately, the fraction of fires which occur in broad daylight, where no other substances are present to provide a visible flame, is estimated to be very low (nearby substances such as roadside grasses, vehicle plastic and rubber components, engine oils, building structures, etc. also become involved). As a result, in many cases the lack of flame luminosity is not a serious concern. Work is continuing toward finding an appropriate luminosity additive to further allay concerns.

Question 10a

Currently the Interagency Commission on Alternative Motor Fuels is conducting a comprehensive assessment of the energy security and other implications of all alternative fuels. The first annual report is scheduled for 1990, and a final report in 1992.

Would our formulation of national policies on alternative fuels not benefit from the Commission's recommendations?

Response

Certainly the Interagency Commission's findings will be very helpful and the Agency is participating in that process. We believe it is important for Congress to include requirements for a clean fuels program in the amendments to the Clean Air Act. With such a Congressional mandate EPA will then establish, through public rulemakings, many of the program details and specifications over the next several years. Therefore, the timing of the Interagency Commission's reports and findings will be very useful as the EPA Administrator makes these decisions.

Question 10b

Your testimony states that such result will assist the EPA Administrator on implementing the President's Clean Fuels Program. What about the more basic question of whether there should be a Federally mandated program in the first place?

Response

Most experts who have studied the issue of new automotive fuels have concluded that it involves a classic chicken-or-egg dilemma: automakers will not invest in new cars without the certainty of convenient fuel availability, and the energy industry will not invest in fuel production and distribution infrastructure until the vehicles are in the fleet. The President's proposal resolves this chicken-and-egg dilemma by ensuring through a Federal mandate that vehicles and fuels are introduced currently and in an orderly fashion.

Question 11

How should the Committee view the agency's alternative fuel program in the context of other actions? Specifically, can this alternative fuels program provide greater long-term benefits than further tightening of the tailpipe standards beyond those contained in S. 1630? What is the answer if fully optimized M85 vehicles are used?

Response

Yes, the alternative fuels program can provide greater long-term benefits since optimized M100 vehicles have only one-third the gasoline VOC-equivalent emissions of gasoline vehicles meeting the stringent tailpipe standards contained in S. 1630. Fully optimized M85 vehicles and gasoline vehicles meeting the standards contained in S. 1630 have similar gasoline VOC-equivalent emissions.

Question 12

From an air quality standpoint, can the gasoline components of M85 fuel be improved in a fashion similar to reformulated gasoline?

Response

From an air quality perspective, the answer is yes. Gasoline reformulations designed to improve air quality will also improve air quality when used to modify the gasoline portion of M85. Specifically, reductions in low-end volatility (i.e., RVP) would reduce evaporative emissions, reductions in aromatic and benzene content would reduce benzene emissions, etc. The only exception may be in the area of oxygenates, where M85 already contains much oxygen. We have not yet investigated how the presence of more oxygenate, particularly an ether like MTBE or ETBE, would affect the optical fuel sensor and, thus, the air-fuel settings of the fuel injector. It is possible that the sensor would adjust for the presence of the oxygenate with little change in emissions or it is possible that some enleanment would occur with a slight reduction in VOC and CO exhaust emissions (only 15 percent of the fuel is affected by the oxygenate).

Practically speaking, the situation is somewhat different. Gasoline is added to methanol for a number of reasons, including flame luminosity and cold startability. With respect to flame luminosity, it is the aromatics which contribute most of the luminosity and some auto manufacturers, such as Ford, have suggested using high aromatic fuel (e.g., 40 percent aromatics by volume) for M85 blending rather than typical fuel containing about 35 percent aromatics. Thus, if the aromatic content of gasoline were reduced substantially (e.g., to 20 volume percent or below), then it appears unlikely that this fuel would be used to blend with M85. Of course, using 40 versus 20 percent aromatic gasoline in M85 has a much smaller effect on the overall aromatic content of the fuel due to dilution by the non-aromatic methanol (six versus three volume percent aromatics, specifically). Thus, either M85 blend would still produce a marked reduction in benzene emissions relative to even 20 percent aromatic gasoline.

With respect to cold startability, adding 9 RVP gasoline to methanol produces M85 with an RVP of around 7.5. Adding 7 RVP gasoline to methanol results in a 6.8 RVP M85. Thus, if current vehicles could start adequately on reformulated gasoline, at least during the summer, they would likely be able to start on reformulated M85. In the winter, however, the vapor pressure of M85 drops quicker with reduced temperature than gasoline. Thus, even without gasoline reformulation, it is likely that the gasoline used in winter M85 would have to have a higher RVP than winter gasoline. This would continue to be true for reformulated gasoline, as well. Of course, evaporative VOC emissions are much less of a concern in the winter due to the absence of an ozone problem in all but a few geographical areas.

Senator Murkowski Questions

Questions 1.2.3

If a market is created for methanol, what will it take to make methanol from Alaska's North Slope competitive in the lower 48 states? What demand? What price? What timeframe?

At what price do you estimate that methanol from Alaska's North Slope can be delivered to the lower 48 states in the near future?

What changes must be made in the existing Alaska oil delivery infrastructure to deliver methanol from Alaska's North Slope to market? Can methanol production and delivery be combined with production and delivery of natural gas liquids? Are there any economic advantages to co-production of natural gas liquids and methanol?

Responses

Vast quantities of natural gas are co-produced with Alaskan oil and are currently reinjected into the oil reservoirs at significant cost, due to the fact that no market for the gas currently exists. This is done in part to maintain oil reservoir pressure for oil production and to conserve the gas resource for future use. At current reinjection rates this gas could be used to produce approximately 14 billion gallons of fuel methanol annually. The price at which such gas could be supplied to a methanol plant could be relatively low, particularly if no other markets are developed for this gas. Jensen Associates, Inc., estimated the price at $0.33/MMBtu.[1] Considering that the current cost of gas reinjection would be displaced, the price of the gas might be even lower.

Although the large reserve of low-cost natural gas makes the North Slope a potential methanol production site, difficulties associated with its Arctic climate make the economics less favorable than other potential methanol plant sites. Two alternatives scenarios exist for producing methanol from Alaskan natural gas: either pipeline transport of natural gas to Valdez with methanol production at the port, or North Slope production of methanol with subsequent pipeline transport of the methanol. Of these two options the latter is probably more practical, since no Trans-Alaska gas pipeline currently exists. The cost of constructing a new gas pipeline would likely be prohibitive.

Even under the latter scenario, however, two major barriers to the use of North Slope gas exist: the high cost of building a methanol plant in a remote Arctic location, and the potentially high cost of transporting methanol from icebound Prudhoe Bay to the lower-48 states. Two studies, one by DOE and one by Bechtel, have estimated the construction cost of a North Slope 10,000 tpd methanol plant to be $1.3-1.5 billion (compared to costs of $0.6-1.1 billion in other areas.)[2,3] These capital costs alone would contribute 18-21¢/gal to methanol production costs. Adding in an additional 9¢/gal for non-gas operating costs and assuming a natural gas price of $0.33/MMBtu yields a plant gate methanol price of 30-33¢/gal . This is within the range of plant gate methanol costs (25-35¢/gal) estimated for other world sites in EPA's special report.

The cost of transporting methanol from Alaska's North Slope could be prohibitive, if a new pipeline were to be built. Bechtel estimated transportation costs from the North Slope to California to be 52¢/gal, 48¢/gal of which would be due to the cost of constructing and operating a new Trans-Alaska methanol pipeline.[3] Transportation cost would be much lower, however, if spare capacity in the existing pipeline could be used.

Previous discussions with the Alaska Oil/Gas Conservation Commission and recent Oil & Gas Journal reports indicate that Alaskan oil production is projected to decline to 50 percent of present levels by 1997 if additional discoveries are not made, creating more than enough spare pipeline capacity to ship 14 billion gallons of methanol.[4-6] Unless new Alaskan oil fields are opened, batch shipping of methanol through the Trans-Alaska pipeline should be possible during the timeframe of the Administration's program. The cost of using this spare capacity would likely be low, since pipeline owners would be faced with either providing pipeline capacity at a price which would allow North Slope methanol to compete, or allowing spare pipeline capacity to remain idle. Thus, it is possible that methanol could be shipped through the Alaska pipeline at relatively low cost assuming no further oil discoveries. The operating cost of the pipeline is estimated at 2-3¢/gal although there is uncertainty about maintenance and upkeep cost. The 4¢/gal estimated by Bechtel for delivery from Valdez to Southern California yields a total transportation cost of 6-7¢/gal. Transportation to the Eastern Coast or Central states would be costlier. On average, North Slope methanol could be provided to the U.S. at a total transportation cost of roughly 8¢/gal, the figure used in the EPA special report.

Thus, if gas were available at $0.33/MMBtu and with spare Trans-Alaska pipeline capacity available, North Slope methanol could be supplied to U.S. port at a price of approximately 40¢/gal. At this price, while marginally cheaper methanol might be available from other sources, the North Slope could compete with other methanol production sites.

As in the case of methanol, any incremental production of propane or butane from Alaska's North Slope could also be transported to Valdez through the Trans-Alaska pipeline. Indeed, at the temperatures prevailing in Alaska, any propane or butane which is currently produced with oil condenses and is either used onsite as fuel or is transported with the crude through the pipeline. This is done at the current pipeline tariff of 12-14¢/gal. Since any propane or butane produced at the well is currently recovered and used, it is unlikely that production will increase in the future while oil production levels continue to decline. Thus, it is not likely that an increase in NGL shipments from the North Slope will occur. The only economic advantage of producing both methanol and NGL would appear related to the production of MTBE. Field butanes from the NGLs could be isomerized and dehydrogenated to produce isobutylene, which could then be reacted with methanol to produce MTBE. This would reduce the volume of fuel required to be pumped through the pipeline and would reduce the need to make the pipeline methanol compatible. However, it would increase the amount of capital needed to be invested on the North Slope. It is also not clear that there would be sufficient butane available to react with the methanol.

With respect to timeframe, five events would have to occur. One, a clear increase in demand for clean fuels would have to occur (e.g., passage of the President's proposal on clean fuels). Two, methanol would have to be the clean fuel of choice by consumers. Three, crude oil volume through the existing pipeline would need to continue to drop off and the pipeline modified to be able to carry both methanol and crude oil. The physical conversion of the pipeline (primarily the pumps) may require no more than two years leadtime. Four, a methanol plant would have to be built. This normally requires 2-3 years. Given the harsh Alaskan conditions, this would likely be extended 1-1.5 years, as estimated by Bechtel in their study for the California Advisory Board on Air Quality and Fuels.[3] Five, the owners of the North Slope gas reserves would not be able to secure a wellhead price for the gas in other markets greater than that secured for methanol production.

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1. "Natural gas Supply, Demand, and Price," James T. Jensen, Jensen Associates, Inc., February 1989.

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3. "California Fuel Methanol Cost Study," prepared by Bechtel, Inc., for Chevron U.S.A., Inc., Amoco Oil Company, ARCO Products Company, California Energy Commission, Canadian Oxygenated Fuels Association, Electric Power Research Institute, Mobil Research and Development Corporation, South Coast Air Quality Management District, Texaco Refining and Marketing, Inc., Union Oil Company of California, January 1989.

4. Personal communication with Mr. Chat Chatterson, Alaska Oil/Gas Conservation Commission, May 8, 1989.

5. "No Quick Turnaround in Sight for Alaskan Oil Production Slide," Bob Williams, Oil & Gas Journal, September 25, 1989.

6. "Alaskan Oil Flow Outlook Dimmed by Tax Threat," Bob Williams, Oil & Gas Journal, October 6, 1989.

Question 4

What can the federal government do to improve the competitiveness of methanol from Alaska's North Slope with methanol from the Middle East and North Africa? What can the federal government do to reduce the cost of development, delivery and production of methanol from Alaska's North Slope?

Response

Implementation of the President's clean fuels proposal would create a demand for clean fuels. This demand may improve prospects for commercial development of North Slope reserves if the demand is for methanol and if North Slope methanol is competitive with other sources of methanol. However, the demand could be for other clean fuels. Production, transport, and distribution of methanol from North Slope gas reserves are largely the responsibility of the private sector. The federal role is limited to thorough regulatory oversight done in a safe and environmentally sound manner. From this standpoint, such oversight should be efficient and effective.

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United States Senate

COMMITTEE ON
ENERGY AND NATURAL RESOURCES

WASHINGTON, DC 20510-6150

October 30, 1989

The Honorable Linda G. Stuntz
Deputy Under Secretary for Policy,
  Planning and Analysis
U. S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D. C. 20585

Dear Ms. Stuntz:

I would like to thank you for your recent appearance at the hearing held by the Committee on Energy and Natural Resources on October 17, 1989, concerning the implications of a switch to methanol as a transportation fuel and the impact of this provision in the President's Clean Air Act on energy policy.

In order to assist the Committee in its consideration of this issue, I am attaching additional questions for inclusion in the hearing record. I would appreciate your sending your responses to Jim Bruce of the Committee staff by November 21, 1989.

Again, thank you for your testimony. I look forward to receiving your additional comments.

Sincerely,

J. Bennett Johnston

J. Bennett Johnston
Chairman

JBJ/jbg

Department of Energy
Washington, DC 20585

February 7, 1990

SENATE COMMITTEE ON
ENERGY AND NATURAL RESOURCES
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WASHINGTON, D.C 20510

The Honorable J. Bennett Johnston
Chairman, Committee on Energy
  and Natural Resources
United States Senate
Washington, D.C. 20510-6150

Dear Mr. Chairman:

I appreciated the opportunity to appear before the Committee on Energy and Natural Resources on October 17, 1989, to discuss methanol as an alternative transportation fuel.

Enclosed, please find replies to questions you asked us to address for the hearing record. I trust you will find these responsive to the Committee's concerns.

Sincerely,

Linda G. Stuntz

Linda G. Stuntz
Deputy Under Secretary
Policy, Planning and Analysis

Enclosure

QUESTIONS FROM SENATOR JOHNSTON

Question 1: **DOE's energy security report states that one major factor limiting the expansion of natural gas use is that the largest portion of world gas reserves (43 percent) is in the U.S.S.R. If the Soviets' gas reserves are excluded, Arab-OPEC states own 50 percent of the world's currently available reserves. Your testimony predicts that the USSR, Arab-OPEC states and Venezuela, another OPEC member, could emerge as powerful methanol producers. Don't these figures give DOE pause from an energy security perspective?**

Answer: The Soviet Union has 38 percent of world gas reserves; 43 percent of the remaining world gas reserves are in Persian Gulf OPEC countries. However, the fact that the USSR and Persian Gulf countries have a large share of world gas reserves does not imply that the potential to enhance U.S. energy security through methanol use does not exist. First, natural gas reserves are more evenly distributed around the world than are oil reserves. Substantial methanol production could come from countries in the western hemisphere, Africa, and Asia. Moreover, even if methanol plants were built in the USSR or in an Arab OPEC country, the government of that country would have strong economic incentives to maintain production because of the high capital cost of methanol plants.

Answer 1:
Continued:

In addition, with reasonable technological progress, we may be able to make methanol from domestic coal or biomass at prices competitive with natural gas-based methanol. The potential for using these alternative feedstocks will discipline sellers of natural gas-based methanol.

Therefore, we think that in the long run the use of methanol as a transportation fuel could have a positive effect on energy security.

QUESTIONS FROM SENATOR JOHNSTON

Question 2: EPA's economic analysis assumes that the worldwide potential gas feedstock for future methanol fuel production would come from 2975 bcf annually flared and vented gas, and 6151 bcf of reinjected gas. EPA describes all of this gas as "low value gas" that would likely attract a portion of the methanol production market.

a) Could you comment on EPA's assumption that a reinjected gas, representing more than twice that which is flared, is low value gas that would go to the methanol production market?

Answer: The value of reinjection varies from one oil field to another. In some instances, it is likely that the gas will have a higher value as feedstock for methanol than for reinjection. In other cases, reinjecting the gas will be necessary to ensure continued oil production.

In addition to the associated gas that is vented, flared, or reinjected, there are substantial quantities, worldwide, of non-associated gas for which there is virtually no market. Some of this gas could be produced at a low cost though the price depends on what resource owners would demand.

QUESTIONS FROM SENATOR JOHNSTON

Question 2b: **Isn't Canadian Arctic gas and Alaskan gas already the subject of pipeline applications, and dedicated to U.S. consumers for home heating, clean electric generation, and industrial uses?**

Answer: Canadian Arctic gas has been subject to pipeline applications for transport to the U.S. for some time. In October 1989 the Canadian National Energy Board conditionally granted licenses for the export of 9 TCF of Canadian Arctic gas to the U.S.

Alaskan North Slope gas has been the subject of similar plans including the ANGST plan to bring gas to the lower 48 states and other plans for export as LNG. Neither of these plans has progressed to the financing or construction stages.

The existing plans for the pipeline use of Canadian Arctic and Alaskan North Slope gas do not mean that these gas fields could not also supply gas for methanol production. The gas fields in these regions are very large and, with proven reserves greater than 65 TCF, may be capable of providing adequate supplies for several different uses, over their productive lives.

QUESTIONS FROM SENATOR JOHNSTON

Question 3: **How would imported methanol stop threats from the supply disruptions resulting from war and terrorism, and manipulation of world markets by a cartel?**

Answer: The use of methanol as a transportation fuel would not eliminate the threat of supply disruptions but could reduce the likelihood or impact of such events by diversifying the source of supply. The geographical pattern of económic methanol production could differ from that of oil production, and as discussed in the answer to question 1, methanol may be made domestically from abundant feedstocks, although such production is currently not price competitive with production from natural gas feedstock. Given the potential for alternate feedstock sources, it would be more difficult for a small group of countries to create a cartel and manipulate the market. Even if a cartel were created, the member countries would have strong economic incentives to maintain production because of the sunk investment in the methanol plants.

QUESTIONS FROM SENATOR JOHNSTON

Question 4: **Are there enough economically recoverable natural gas resources in the world to shift the U.S. from gasoline to methanol as the predominant vehicle fuel without resorting to coal as a feedstock?**

Answer: If the United States were to rely on gas derived methanol for 50 percent of vehicle fuel use, it would require an increase in world natural gas production of about 20 percent. Since it is likely that nearly all of this methanol would be imported, there could be little effect on domestic natural gas production. It is likely that world gas reserves are sufficient to provide increased production to support this incremental demand. Current proved world gas reserves are 3955 TCF and are produced at an average depletion rate of 1.7 percent. A 20 percent increase in production would raise the depletion rate to 2 percent, compared to an average world depletion rate of 2.2 percent for oil. In addition, even under the most aggressive scenarios of methanol use, it would take at least several decades before methanol could play this large a role.

QUESTIONS FROM SENATOR JOHNSTON

Question 5: You say in your testimony that neat methanol derived from natural gas using current technologies would cost from under 40 cents to over 50 cents per gallon. What does that work out to as a gasoline equivalent price at the pump?

Question 5a: It's about $1.50 per gallon isn't it? (Note: A draft DOE report on methanol costs arrives at this result) That isn't price competitive with gasoline is it?

Answer: The cost of producing methanol depends on a great many factors, including cost of the feedstock, plant size and location, capital recovery rate, and transportation costs. The attached table presents estimates of the costs of methanol using current and advanced technologies at a relatively accessible site with some developed infrastructure. The transportation distance is assumed to be 6,000 miles (one-way). The gasoline equivalent price at the pump for M85 produced using current technologies is $1.38 per gasoline-equivalent gallon with no vehicle efficiency improvements and a realized price of $1.30 with a six percent vehicle efficiency improvement. Methanol produced with the current technology would not be competitive with gasoline at today's prices, but may become economic in the future with advanced technology.

Question 5b:
continued:

The advanced technology plant would get you to about $1.20 per gallon in gasoline equivalent terms. Thus, it is more expensive than regular gasoline, but perhaps the same as premium?

Answer:

As is shown in the attached table, the retail price of M85 on a gasoline-equivalent basis, using advanced technology, would be $1.11 with a six percent vehicle efficiency improvement, which is in the range of current gasoline prices. These estimates are based on a regular gasoline price of $1.10 per gallon. If crude oil prices increase above present levels, both gasoline and methanol prices would increase as well. Methanol prices could change at rates different from other fuel prices. For instance, it may rise at a slower rate than gasoline prices, because methanol production is more capital intensive and because the price of foreign natural gas feedstock does not always track closely the price of crude oil, on the other hand methanol prices could rise at a faster rate depending on what resource owners demand for their gas.

QUESTIONS FROM SENATOR JOHNSTON

Question 5c: If you add up the cumulative capital investment in methanol plants, vehicles, and refueling outlets listed in your testimony, the total is over $10 billion. Is that right?

Answer: The cumulative capital costs in constant 1988 dollars for fuel production facilities, fuel distribution outlets and vehicles range from about $8 to $10 billion by 2004. These capital costs are discussed more fully in the testimony.

QUESTIONS FROM SENATOR JOHNSTON

Question 5d: **The carrying cost for that capital investment is roughly about $1 billion per year? But you are only affecting 1 million cars per year in annual production. That's $1,000 in capital invested for every car produced to run on methanol. Am I looking at that right? Isn't that pretty expensive? Won't the consumer pay that ultimately?**

Answer: The actual "carrying costs" or interest charges would depend on the borrowing cost of money as well as the amount of debt versus equity used to finance the investment. However, the $1 billion figure is an adequate approximation of the annual cost, but this cost is not necessarily all borne by the United States.

In 2004 there would be a total of about 9 million methanol vehicles on the road. Thus the annual "carrying cost" (interest on the capital investment) is on the order of $100 per vehicle. This cost will be reflected in the cost of fuel as well as the cost of the vehicle, both of which the consumer would have to pay.

However, this cost would have to be balanced against any savings from reduced damage from air pollution and the corresponding cost of achieving comparable reduction from conventional gasoline vehicles.

QUESTIONS FROM SENATOR JOHNSTON

Question 5e: **How would a switch to methanol as the primary U.S. transportation fuel affect domestic natural gas, crude oil, and retail gasoline prices if methanol used (a) foreign natural gas, or (b) domestic natural gas as a feedstock?**

Answer: A substantial substitution of methanol for gasoline would reduce the demand for gasoline and increase the demand for natural gas as a methanol feedstock. This could put downward pressure on the prices of crude oil and petroleum products. Since natural gas and oil compete in the boiler fuel market, lower-priced petroleum products would capture a larger share of the boiler fuel market from domestic natural gas. If foreign natural gas were used to produce methanol, any loss of domestic boiler fuel markets would, in turn, put downward pressure on domestic gas prices.

However, if the methanol used domestic natural gas as a feedstock, the increased demand for domestic gas would put upward pressure on domestic gas prices, more than offsetting the downward price pressure resulting from the loss of boiler fuel markets.

TABLE FOR QUESTION 5

ESTIMATED METHANOL PRICES

Methanol plant technology	Current	Advanced
Capital recovery	$0.21	$0.12
Operating costs		
natural gas*	$0.11	$0.10
other	$0.10	$0.06
Plant gate cost	$0.42	$0.28
Shipping cost	$0.06	$0.06
Mark-up (M100)	$0.26	$0.26
M100 price, per gallon	$0.74	$0.60
M85 price, per gallon	$0.80	$0.68

GASOLINE EQUIVALENT PRICES

Methanol plant technology	Current		Advanced	
Vehicle efficiency improvement	None	6 %	None	6 %
M100	$1.48	$1.39	$1.20	$1.13
M85	$1.38	$1.30	$1.18	$1.11

FOOTNOTES

* Natural gas is assumed to cost $1.10/mcf.

** The retail price of gasoline is assumed to be $1.10.

QUESTIONS FROM SENATOR JOHNSTON

Question 6: You say that using natural gas as a fuel directly or as a feedstock for methanol would improve the global climate change situation, is that right?

You say that making methanol from coal would increase CO_2 emissions unless "the heat required to provide methanol were provided by an energy source that did not generate CO_2 emissions." What kind of heat source are you talking about?

Answer: Yes, that is the correct interpretation of my testimony. Examples of energy sources (for methanol production from coal) that don't result in a net increase in CO_2 include electricity from solar, hydro and nuclear sources.

QUESTIONS FROM SENATOR JOHNSTON

Question 7: **When do you think we will know what the economic and technological potential is for making methanol from biomass?**

Answer: The Department of Energy is examining the potential for producing methanol from biomass. We expect to complete our study before the end of fiscal year 1990.

QUESTIONS FROM SENATOR JOHNSTON

Question 8: I understand that a number of countries are serious about trying to reduce or offset their emissions of CO2 from the burning of fossil fuels. There is a meeting scheduled this November in the Netherlands, I understand, in which this issue will arise and the U.S. is invited.

In planning the National Energy Strategy, what is being done to address this issue of limiting our emissions of CO2?

Answer: The United States Government is committed to achieving an international consensus on any possible response strategy to address potential climate change. The Intergovernmental Panel on Climate Change (IPCC) is the principal forum for developing that consensus, in the Administration's view. The Noordwijk Declaration, resulting from the November meeting referenced in this question, and signed by the U.S., recognizes the need to stabilize, while ensuring stable development of the world economy, CO2, emissions and emissions of other greenhouse gases not controlled by the Montreal protocal. The Noordwijk Declaration also urges all industrialized countries to support the IPCC, which is now conducting scientific, technical and response strategy assessments.

Domestically, the National Energy Strategy (NES) process is the principal vehicle for developing

Answer 8 continued:

energy policies that address the need to limit greenhouse gas emissions. The NES will draw upon the extensive work that the Department of Energy is doing for the IPCC. It will also draw upon global climate change reports being prepared at the request of Congress, including a report evaluating policies to achieve a 20% CO2 reduction in 5-10 years, and a 50% reduction in CO2 in a 15-20 year period. (See P.L. 101-101, S.R. No. 100-381.)

In addition to this ongoing analytical work, DOE's National Laboratories have been asked to assess the science on the contribution of CO2 to climate change. DOE also held a public hearing on December 14 to foster public debate on global climate change issues, and help build a national consensus on desirable and effective energy policy measures to address greenhouse gas emissions.

QUESTIONS FROM SENATOR JOHNSTON

Question 9: **Your testimony refers to the potential for economically producing methanol from coal if it is combined with cogeneration of electricity. What would producers do with the CO_2 produced? How much would facilities for addressing the CO_2 problem cost?**

Answer: CO_2 is produced both by the operation of gasoline powered motor vehicles and from the production of electric power from coal, using conventional technologies. If fuel methanol were produced from coal as part of an electricity cogeneration process, CO_2 would still be produced and released into the atmosphere. However, the overall efficiency of the methanol/electricity cogeneration process is high enough to offset the normal increase in CO_2 associated with coal-to-methanol production. This would mean that if methanol produced from this process was substituted for gasoline, there would be no net increase in CO_2 released to the atmosphere.

The CO_2 produced during the production of methanol by this cogeneration process at large plants are amenable for capture by technologies under development. However, our view of this as a possible methanol production process does not include, or depend on, the further control of CO_2. Separate studies of CO_2 collection and disposal have indicated that there is a limited market for CO_2 as a usable product and that CO_2 disposal, such as pumping it into deep sea beds, would be very expensive with unknown environmental impacts.

QUESTIONS FROM SENATOR JOHNSTON

Question 10: **What volumes of CO2 would be anticipated for M85 in the nine-non-attainment areas in 1995? 2000? 2005? How about M100 in those areas in 2000? 2005? What if the whole U.S. transportation sector switched to M100 by the year 2010? How do these volumes of CO2 compare with the volumes of natural gas produced domestically each year from formations that could permanently contain injected CO2?**

Answer: Exhibit 1 demonstrates CO2 vehicle emission reductions in ozone non-attainment areas if flexible-fuel vehicles (FFVs) using M85 were phased in according to the requirements of the proposed Clean Air Act Amendments "Clean Fuels" Program. These figures do not include CO2 emissions from fuel production activities from either methanol or gasoline. Reductions range from 0.2 to 2.9 billion pounds per year over the years 1995 to 2010. The range is due to the increasing penetration rate of methanol vehicles. These reductions represent about one-half of one percent of the CO2 emissions from these automobiles.

Exhibit 2 demonstrates CO2 reductions in ozone non-attainment areas if FFVs using M100 were phased in according to the requirements of the proposed Clean Air Act Amendments "Clean Fuels" Program. Reductions ranged from 0.3 to 3.9 billion pounds per year over the years 1995 to

Answer 10 continued:

2010. The range is also due to the increasing penetration of methanol vehicles.

Exhibit 3 demonstrates nationwide CO2 reductions if all of the gasoline used in the U.S. transportation sector was replaced with M100. Reductions range from 517.5 to 549.2 billion pounds per year over the years 1995 to 2010. These reductions represent about a four percent decline in CO2 emissions from automobiles.

For the year 2010 the projected emissions of CO_2 from full M100 use are 12.6 trillion pounds (103 trillion cubic feet) per year. EIA's preliminary projection for domestic natural gas production in 2010 is 19.8 trillion cubic feet. Simplified volumetric comparison shows projected annual CO_2 emissions from M100 five times greater than annual methane production for the year 2010. It should be noted that not all reservoirs that produce natural gas are compatible with injection of CO_2.

The use of depleted oil and gas reservoirs as permanent storage sites for CO_2 requires additional analysis qualified by the following information. Simultaneous injection of CO_2 and

Answer 10
continued:

withdrawal of natural gas from the same reservoir is not technically feasible. The rate at which compatible gas reservoirs would be available in the year 2010 is a projection that cannot be made from available data bases. Oil reservoirs at their economic limit or amenable to CO_2 injection for enhanced oil recovery represent another permanent storage possibility that would require analysis. Capture, transport, and injection of CO_2 at this order of magnitude would require a significant infrastructure which does not presently exist.

CO2 EMISSIONS WITH FFV PHASE-IN (USING M85):

	YEAR			
	1995	2000	2005	2010
Neat Methanol Used in FFVs (billion gal/yr)	0.5	3.8	6.0	7.3
Gasoline Used in FFVs (billion gal/yr)	0.1	0.7	1.1	1.3
Gasoline Used In Non-FFVs (billion gal/yr)	23.2	23.7	24.0	24.2
CO2 Emissions From Methanol Used in FFVs (billion lb/yr)	4.5	34.3	54.1	65.9
CO2 Emissions From Gasoline Used In FFVs (billion lb/yr)	1.7	12.8	20.2	24.6
CO2 Emissions From Gasoline Used In Non-FFVs (billion lb/yr)	442.7	452.2	457.9	461.7
Total CO2 Emissions (billion lb/yr)	448.9	499.3	532.3	552.2

IF METHANOL WERE REPLACED WITH GASOLINE IN ABOVE SCENARIO:

	YEAR			
	1995	2000	2005	2010
Gasoline Displacing Methanol (billion gal/yr)	0.2	1.9	3.0	3.6
Gasoline Used (from above) (billion gal/yr)	0.1	0.7	1.1	1.3
Gasoline Used In Non-FFVs (billion gal/yr)	23.2	23.7	24.0	24.2
CO2 Emissions From Gasoline Displacing Methanol (billion lb/yr)	4.7	35.8	56.5	68.7
CO2 Emissions From Gasoline Used (from above) (billion lb/yr)	1.7	12.8	20.2	24.6
CO2 Emissions From Gasoline Used In Non-FFVs (billion lb/yr)	442.7	452.2	457.9	461.7
Total CO2 Emissions (billion lb/yr)	449.0	500.8	534.6	555.0
CO2 Emissions Reduction (billion lb/yr)	0.2	1.5	2.4	2.9

EXHIBIT 1. COMPARISON OF CO2 EMISSIONS WITH AND WITHOUT FFV PHASE-IN IN NON-ATTAINMENT AREAS (ASSUMING FFVs USE M85).

CO2 EMISSIONS WITH FFV PHASE-IN (USING M100):

	YEAR			
	1995	2000	2005	2010
Neat Methanol Used In FFVs (billion gal/yr)	0.7	5.2	8.1	9.9
Gasoline Used In Non-FFVs (billion gal/yr)	23.2	23.7	24.0	24.2
CO2 Emissions From Methanol Used In FFVs (billion lb/yr)	6.1	46.5	73.5	89.4
CO2 Emissions From Gasoline Used In Non-FFVs (billion lb/yr)	442.7	452.2	457.9	461.7
Total CO2 Emissions (billion lb/yr)	448.8	498.7	531.4	551.2

IF METHANOL WERE REPLACED WITH GASOLINE IN ABOVE SCENARIO:

	YEAR			
	1995	2000	2005	2010
Gasoline Displacing Methanol (billion gal/yr)	0.3	2.5	4.0	4.9
Gasoline Used In Non-FFVs (billion gal/yr)	23.2	23.7	24.0	24.2
CO2 Emissions From Gasoline Displacing Methanol (billion lb/yr)	6.4	48.6	76.7	93.3
CO2 Emissions From Gasoline Used In Non-FFVs (billion lb/yr)	442.7	452.2	457.9	461.7
Total CO2 Emissions (billion lb/yr)	449.0	500.8	534.6	555.0
CO2 Emissions Reduction (billion lb/yr)	0.3	2.0	3.2	3.9

EXHIBIT 2. COMPARISON OF CO2 EMISSIONS WITH AND WITHOUT FFV PHASE-IN IN OZONE NON-ATTAINMENT AREAS (ASSUMING FFVs USE M100).

	YEAR			
	1995	2000	2005	2010
Neat Methanol Used (billion lb/yr)	1319.4	1345.8	1372.7	1400.2
CO2 Emissions From Methanol Used (billion lb/yr)	11903.5	12141.6	12384.4	12632.1
Gasoline Used (billion lb/yr)	651.0	664.0	677.3	690.8
CO2 Emissions From Gasoline Used (billion lb/yr)	12421.1	12669.5	12922.9	13181.3
CO2 Emissions Reduction (billion lb/yr)	517.5	527.9	538.5	549.2

EXHIBIT 3. CO2 EMISSIONS IF ALL U.S. TRANSPORTATION SECTOR USED M100 INSTEAD OF GASOLINE.

QUESTIONS FROM SENATOR JOHNSTON

Question 11:	From your testimony I take it that you anticipate that methanol may require cross subsidies between itself and gasoline to create the necessary demand for methanol. Is that correct?
Answer:	The testimony raised the issue of cross-subsidization of methanol prices only to indicate the small effect such a subsidy would have on gasoline prices. Because of uncertainty over future methanol and gasoline prices we are not now in a position to say whether any subsidization would be required.

QUESTIONS FROM SENATOR MCCLURE

Question 1: If the President's Clean Fuel Program were fully implemented, what would be the percentage incremental benefits attributed to the alternative fuels program, if M85 were the fuel of choice? If M100 were the fuel of choice?

Answer: The Department of Energy has not studied the incremental benefits, in achieving ambient air quality standards, of M85 and M100 use. We defer to the Environmental Protection Agency on this issue.

QUESTIONS FROM SENATOR MCCLURE

Question 2: In a 1987 report to the Vice President's Task Force on Alternative Fuels, EPA estimated the reductions in ozone levels that would occur in New York, Washington, D.C. and Los Angeles by introducing current and advance technology methanol vehicles. EPA concluded that replacing 15 percent of vehicle miles traveled in these three cities would reduce ozone levels by a maximum of 1.7 percent. So-called "advanced methanol" technology was projected to achieve reductions of 3 to 4.5 percent by the year 2000. Do you agree with this assessment? If not, why not?

Answer: As stated in answer to question 1, the Department of Energy has not done independent analysis to confirm or deny the ozone percentage reductions contained in EPA's 1987 Report to the Vice President.

QUESTIONS FROM SENATOR MCCLURE

Question 3: In September 1989, EPA released its latest assessment of the air quality impacts of methanol use. The agency concluded that if the vehicles under President Bush's clean air proposal were dedicated to M100 after 1990 ozone levels in the year 2005 would be reduced by an average of 1.5 percent in nine of the nation's more polluted cities and the maximum benefit by the year 2015 would be 3.3 percent. Do you agree with this assessment? If not, why not?

Answer: The EPA Office of Mobile Sources issued a Special Report in September 1989 titled Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel. The percent reductions cited of 1.5 percent in the year 2005 and 3.3 percent in the year 2015 are for volatile organic compounds (VOCs) reductions and not ozone. DOE has not conducted independent analysis of methanol emission characteristics that would allow us to agree or disagree with EPA's assessment.

QUESTIONS FROM SENATOR MCCLURE

Question 4: A July 1989 report by the Office of Technology Assessment estimates the cost of removing hydrocarbons from the ambient air by the use of methanol vehicles is $30, 000 per ton. This cost compares to $1,000 to $5,000 per ton for other technologies such as limiting gasoline volatility ($500 per ton), capturing vapors with special fuel pumps at filling stations ($1,000 per ton), or strengthening inspection and maintenance programs ($4,000 per ton). According to OTA, the most expensive method is replacement of gasoline with methanol, at $8,700 to $51,000 per ton of reductions. Do you agree with these estimates? If no, why not?

Answer: DOE has not undertaken the emissions analysis necessary to evaluate OTA's report. We defer to EPA which has recently completed analyses pertinent to OTA's report.

QUESTIONS FROM SENATOR MCCLURE

Question 5: What would be the capital investment (in production facilities, vehicles, refueling outlets, etc.) required to implement the President's Clean Fuels Program?

a. if methanol were the fuel of choice?
b. if natural gas were the fuel of choice?
c. if reformulated gasoline were the fuel of choice?
d. and for other feasible alternative fuels?

Answer: DOE has made preliminary estimates of the capital costs for implementing the President's Clean Fuels Program. As indicated in the testimony these cost estimates cover fuel production, fuel distribution outlets, and additional vehicle costs. These costs do not include any additional infrastructure needed to provide fuel to service outlets, such as methanol terminals, tank trucks or distribution pipelines. For methanol the cumulative cost for 2004 would be $8 to $10 billion, the majority of which is for the fuel production. This would not necessarily all be a U.S. investment. For compressed natural gas the cumulative cost would be about $10 billion, the majority of which is for vehicles. In the case of electric vehicles, the capital costs are much higher (on the order of $50 billion) but this comparison is misleading because it would be highly unlikely that the President's program could be fulfilled by the

Answer 5 continued:

exclusive use of electric vehicles, given their cost and performance limitations.

DOE does not have an estimate of the capital costs of reformulated gasoline but these costs would be almost all associated with changes in refineries.

QUESTIONS FROM SENATOR McCLURE

Question 6:	**There is considerable dispute regarding the costs of methanol derived from natural gas feedstock. The Department of Energy estimated that the cost of methanol derived from natural gas ranges from under 40 cents per gallon to over 50 cents per gallon. (When answering the following question indicate both the costs per gallon of methanol and the costs per gallon of gasoline equivalent.)**
Question 6a:	**What assumptions were made in deriving these estimates? In particular, what were the assumption regarding the price of natural gas?**
Answer:	The cost of producing methanol depends on a great many factors, including cost of the feedstock, plant size and location, capital recovery rate, and transportation costs. The attached table presents estimates of the costs of methanol using current and advanced technology. Natural gas is assumed to cost $1.10 per million BTUs. The plant is sited in a remote location that has existing infrastructure, such as Venezuela or Saudi Arabia. The transportation distance is assumed to be 6,000 miles (one way). In calculating M85 costs, gasoline is assumed to have a pump price of $1.10 per gallon. Using current technology, the retail price of M85 is about $1.38 per gasoline

Answer 6 continued:

equivalent gallon assuming no vehicle efficiency improvements and $1.30 assuming a six percent vehicle efficiency improvement. With advanced technology, these prices are $1.11 assuming six percent efficiency improvement.

QUESTIONS FROM SENATOR MCCLURE

Question 6b: **What assumptions were made regarding the Federal and State tax treatment?**

Answer: The 40 to 50 cents per gallon methanol estimate is at the plant gate and includes only production costs, and does not include any transportation or distribution costs or state or federal taxes. These additional costs are displayed in the attached table.

TABLE FOR QUESTION 6

ESTIMATED METHANOL PRICES

Methanol plant technology	Current	Advanced
Capital recovery	$0.21	$0.12
Operating costs		
natural gas*	$0.11	$0.10
other	$0.10	$0.06
Plant gate cost	$0.42	$0.28
Shipping cost	$0.06	$0.06
Mark-up (M100)	$0.26	$0.26
M100 price, per gallon	$0.74	$0.60
M85 price, per gallon	$0.80	$0.68

GASOLINE EQUIVALENT PRICES

Methanol plant technology	Current		Advanced	
Vehicle efficiency improvement	None	6 %	None	6 %
M100	$1.48	$1.39	$1.20	$1.13
M85	$1.38	$1.30	$1.18	$1.11

FOOTNOTES

* Natural gas is assumed to cost $1.10/mcf.

** The retail price of gasoline is assumed to be $1.10.

QUESTIONS FROM SENATOR MCCLURE

Question 7: **From the standpoint of overall energy efficiency, what is the comparable energy efficiency of an automobile which uses gasoline as a fuel?, methanol derived from natural gas?, methanol derive from coal?, compressed natural gas?, gasohol?, reformulated gasoline?, other alternative fuels?**

Answer: The Department of Energy has not specifically studied the "overall energy efficiency" of the various fuels. However, defining this term as the most energy output per unit of energy input, and based on the analyses reported in the literature, a ranking is possible. The ranking accounts only for non-renewable energy (oil, gas, coal, electricity) and not the solar content of a fuel like ethanol. On this basis, the comparative efficiency of the fuels are:

Highest Efficiency - Ethanol
Gasoline
Reformulated Gasoline
Compressed Natural Gas
Electricity
Methanol from Natural Gas
Lowest Efficiency - Methanol from Coal

This ranking should not be considered definitive since it is based on a number of assumptions that can change and on the work of several analysts that is not always comparable.

QUESTIONS FROM SENATOR MCCLURE

Question 8: **What are the public health and safety risks associated with the wide-spread use of methanol? For example, what are the hazards of spilling methanol on your hands when filling your car's gas tank? We all have experienced this problem at one time or another.**

Answer: Methanol is a mild eye irritant upon direct contact. It causes irritation of the eyes, nose and throat when inhaled above the current recommended workplace exposure limit of 200 ppm. Under conditions of prolonged exposure, such as saturated clothing, methanol may cause serious toxicity.

Methanol poses a higher risk of systemic toxicity (depression, dizziness, nausea, breathing difficulties) and severe outcomes such as permanent blindness, neurologic impairment, or even death if appropriate treatment is not obtained promptly than gasoline does. The ingested dose which requires immediate treatment

Answer 8 Continued:

is 0.4 ml of methanol/kg of body weight -- a teaspoonful (5 ml) of M85 fuel in a 10-kg one-year-old child, and about 28 ml (less than an ounce) in a 70-kg adult. Such an amount can be swallowed in a siphoning accident by a young adult. Methanol can be fatal after ingestion of only 80-150 ml (3-5 oz).

Prior to conversion to a predominantly methanol fleet, innovative closures and mechanical devices/techniques must be developed which prevent siphoning, and limit access by small children. Public and health education will be required, focusing on the lethal consequences, the need to prevent accidental ingestion, and the urgency with which treatment must be undertaken. Container transfer should be discouraged and clear, emphatic warning labels prominently displayed on fuel containers and around the fuel tank orifice of each vehicle.

QUESTIONS FROM SENATOR McCLURE

Question 9: Currently the Interagency Commission on Alternative Motor Fuels is conducting a comprehensive assessment of the energy security and other implications of all alternative fuels. The first annual report is scheduled for 1990, and a final report in 1992.

a: Would our formulation of national policies on alternative fuels not benefit from the Commission's recommendations?

b. Your testimony states that such results will assist the EPA Administrator on implementing the President's Clean Fuels Program. What about the more basic question of whether there should be a Federally mandated program in the first place?

Answer: The mandate for the Interagency Commission on Alternative Motor Fuels, established by the Alternative Motor Fuels Act, is to recommend policies which would lead to the widespread commercialization of alternative motor fuels.

The findings of the Interagency Commission and its advisory body, the U.S. Alternative Fuels Council, will be available to assist the EPA Administrator in implementing the President's Clean Fuels Program. However, the President's Clean Fuels Program does not, in itself, define the future of alternative fuel use in the U.S. It is a limited, fuel neutral program, established for a specific time period, and for limited geographical areas, to achieve specific environmental objectives. It may facilitate the introduction of alternative fuels by providing large scale operating experience with one or more alternative fuels though it is designed to allow all clean fuels, including reformulated gasoline, to compete.

QUESTIONS FROM SENATOR MURKOWSKI

Question 1: **If a market is created for methanol, what will it take to make methanol from Alaska's North Slope competitive in the lower 48 states? What demand? What price? What time frame?**

Answer: Methanol produced on the North Slope of Alaska is estimated to cost about $.40 more per gasoline-equivalent gallon (for M85) at the pump than methanol produced in several foreign countries. The higher cost is attributable to differences in plant construction costs, operating costs, and transportation costs. The Department has not examined the time frames nor the particular conditions under which methanol produced from North Slope gas could be competitive with methanol produced in other regions of the world.

QUESTIONS FROM SENATOR MURKOWSKI

Question 2: **At what price do you estimate that methanol from Alaska's North Slope can be delivered to the lower 48 states in the near future?**

Answer: Using advanced technology and assuming a natural gas price of $.50/mcf, the cost of producing methanol on the North Slope is estimated to be about $.40 per gallon at the plant gate. If the methanol can be transported through the Trans Alaska Pipeline at a cost of $.05 per gallon, the price of M85 at the pump in California would be about $.80 per gallon, or approximately $1.40 per gasoline equivalent gallon. It should be noted that the feasibility of transporting methanol through TAPS is disputed and has not been studied by DOE.

QUESTIONS FROM SENATOR MURKOWSKI

Question 3:	**What changes must be made in the existing Alaska oil delivery infrastructure to deliver methanol from Alaska's North Slope to market? Can methanol production and delivery be combined with production and delivery of natural gas liquids? Are there any economic advantages to co-production of natural gas liquids and methanol?**
Answer:	The Department of Energy is studying these questions, for consideration by the Interagency Commission on Alternative Motor Fuels, and will be able to answer these questions shortly.

QUESTIONS FROM SENATOR MURKOWSKI

Question 4: **What can the federal government do to improve the competitiveness of methanol from Alaska's North Slope with methanol from the Middle East and North Africa? What can the federal government do to reduce the cost of development, delivery and production of methanol from Alaska's Slope?**

Answer: Assuming that the existing Alaska pipeline could be used to ship methanol as well as crude oil, (as discussed earlier, this is subject to considerable dispute) there is little else that can be done technically to reduce the cost of methanol production and transportation from the North Slope. Financially, reducing uncertainty in methanol demand and market price may improve prospects for commercial development of larger (mega) plants and thus reduce the cost per unit of methanol. Production, transportation, and distribution of methanol from North Slope reserves is largely the responsibility of the private sector.

The Federal Government's role is limited to thorough regulatory oversight done in a safe, environmentally sound manner. From this standpoint, such oversight should be efficient and effective.

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John H. Gibbons
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Congress of the United States
Office of Technology Assessment
Washington, DC 20510-8025

November 20, 1989

The Honorable J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

Enclosed are answers to the questions the Committee asked of Steven Plotkin and me for inclusion in the October 17 hearing record. We have answered as many as possible given the time and data available. We hope you find them helpful.

Sincerely,

Robert M. Friedman

Robert M. Friedman
Senior Associate

Enclosure

Answers to Senator Johnston's Questions:

1) In your report, "Catching Our Breath", OTA ranked methanol against other emission reduction strategies and concluded methanol was the least cost-effective. What were the other emission reduction strategies?

We analyzed about 60 currently available control methods that together deal with sources producing about 85 percent of current VOC emissions. These include:

- o Lowering the volatility of gasoline to curtail evaporation from vehicles' fuel tanks (including so-called "running losses" while the vehicle is moving).
- o Stricter controls on facilities that treat, store, and dispose of hazardous wastes (TSDFs).
- o Applying all "reasonably available control technology" (RACT-level) controls now found in any State's ozone control plan to all nonattainment areas' sources larger than 25 tons. (About 40 types of sources, such as petroleum refineries, chemical manufacturers, print shops, and drycleaners, were included.)
- o Enhanced programs to inspect cars and trucks and require maintenance of faulty pollution controls (over and above the reductions achieved by the inspection and maintenance programs in operation today).
- o Modifying the nozzles of gas station pumps to trap escaping vapors (called "Stage II gasoline vapor recovery systems"). In addition, we analyzed devices to do the same job on individual vehicles as they fuel up ("onboard technology").
- o Regulations for several smaller, currently unregulated categories of stationary sources, such as autobody refinishing and wood furniture coating shops, coke oven byproduct plants, and bakeries.
- o Requiring businesses that operate fleets of 10 or more vehicles in the worst nonattainment areas to substitute methanol for gasoline.
- o Limits on the solvent content in architectural coatings such as paints and stains.

- o More stringent standards for tailpipe emissions from gasoline-powered cars and light-duty trucks.

The attached figure summarizes our estimates of the cost effectiveness of reductions for each of these categories.

2) **Why shouldn't the Federal Government let California proceed with its plans for methanol and be the voluntary methanol guinea pig -- and meanwhile, the Federal Government should adopt other more cost-effective alternative emission reduction strategies, even though they may not have the ultimate potential of methanol?**

Our analysis indicates that currently available control methods can bring into compliance about half of all areas that now fail to attain the standard for ozone. None of the current bills require methanol vehicles in these areas. For the other half of the areas -- including such major metropolitan areas as New York, Los Angeles, Chicago, and Houston -- the issue is not which of the existing control methods do we want to choose to adopt, but rather what is the best approach for developing new and cost effective controls. All of the current bills specify that each of these areas must adopt all existing, cost-effective control methods.

The Administration bill relies on alternative fuels as the single new control method that will bring the worst nonattainment areas into compliance. The Federal Government may be better off researching and demonstrating several approaches -- controls on solvents, nitrogen oxide emissions, as well as alternative fuels such as methanol and compressed natural gas -- rather than relying on just one. While much will be learned from California's methanol program, a Federal program that applies to other cities would certainly help to determine the potential for methanol vehicles.

3) a. What is your view of the potential for reformulated gasoline?

"Reformulated gasoline" is now primarily a concept rather than a reality: ARCO's EC-1 gasoline, available in limited quantities in California, is the only example extant. The potential of this fuel will depend on three factors:

- *The emissions reductions achievable.* Industry analysts have been speculating that a total decrease of about 30 percent in "reactive hydrocarbon equivalent" may be possible with an advanced formulation of reformulated gasoline, that is, about what is expected from an 85 percent methanol/15 percent gasoline blend (M85).
- *The standards it must meet as a competing "alternative fuel."* If Congress or EPA establishes an alternative fuels program with emissions standards based on the capabilities of M85 in flexible fuel vehicles, reformulated gasoline may be able to qualify. However, the current Administration proposal foresees a more stringent second stage standard, probably based on the capabilities of straight methanol, "M100" (about an 80-90 percent reduction in reactive hydrocarbons from current levels); reformulated gasoline is highly unlikely to qualify under such a standard.
- *The cost of the fuel compared to the costs of competing fuels.* Future costs of reformulated gasoline are unknown, but early industry speculation is that they are likely to be 5 to 15 cents per gallon more expensive than unleaded regular. Available estimates of alternative fuel costs range from well above current gasoline prices (adjusted for energy content) to slightly below these prices (e.g., the EPA projected costs for M100). If the EPA is right, and M100 were cheaper than ordinary gasoline, reformulated gasoline would not compete well with methanol. OTA believes EPA is being overoptimistic about methanol costs, that these costs are likely to be higher than current gasoline costs, especially in the near term, and that reformulated gasoline, if it is 5 to 15 cents per gallon more expensive than gasoline, will likely be cost-competitive with methanol.

b. What is your view of the potential for compressed natural gas?

Compressed natural gas (CNG) *in dedicated (single fuel) vehicles* is promising from the standpoint of fuel cost, engine maintenance, toxicity, ease of engine design, and emissions reduction potential, but may have problems with consumer acceptance and industry interest (dual fuel vehicles appear to have far less promise than dedicated vehicles). It appears that the automobile industry has put considerably more resources into methanol than CNG, presumably because of methanol's liquid form and the industry's familiarity with methanol as a racetrack fuel, possibly also because of industry's perception that CNG vehicles may not appeal to consumers. OTA believes that consumer acceptance of the changes in refueling required by CNG vehicles is the crucial issue affecting the potential for such vehicles. The future degree of such acceptance cannot be predicted.

CNG appears to have substantial market potential for transit buses and possibly for fleet vehicles as well. A CNG-powered bus was delivered recently to the Columbus, Ohio transit system, and more attention seems to have been paid to developing optimal gas-powered heavy-duty engines than to light-duty engines. Refueling changes should be less of an issue with these vehicles.

4) Elaborate on your statement that "energy security considerations appear to conflict with air quality goals (with regard to dual fuel vehicles versus dedicated vehicles)."

Dedicated alternative fuel vehicles *can* have energy security benefits, by reducing gasoline consumption and thus lessening the economic impact of a sudden rise in gasoline prices. With a large fleet of dedicated methanol vehicles, the reduction in economic impact from a price shock would be directly proportional to the amount of methanol used in place of petroleum, assuming methanol prices were not somehow tied to gasoline prices. There are, however, other security concerns not addressed by a dedicated methanol fleet. Dedicated vehicles do not guard against impacts from actual gasoline shortages, because a shortfall of a million barrels per day of gasoline would have precisely the same impact whether part of the fleet used methanol or not. And security pressures on *methanol* could arise from a dedicated fleet. In contrast, a fleet of flexible fuel vehicles will use whichever fuel is cheaper, assuming sufficient supplies are available. If gasoline prices spike, more of these vehicles would turn to methanol (assuming they had not already unanimously selected methanol), reducing gasoline demand and lessening market pressure on gasoline prices. In addition, those vehicles already using methanol could turn to gasoline if methanol shortages developed or if methanol prices spiked. Consequently, flexible fuel vehicles will be more useful than dedicated vehicles in improving energy security. Unfortunately, flexible fuel vehicles will not yield nearly as great an environmental benefit as dedicated vehicles. EPA postulates a 30 percent reduction in reactive emissions from flexible fueled vehicles, 80-90 percent reduction from dedicated M100 vehicles.

Answers to Senator McClure's Questions:

1) a. What are the most likely sources of methanol? Would you agree with the Department of Energy's assessment that the principle supplier of methanol will be Argentina, Chile, North Africa, and the Middle East?

We were not under the impression that the Department of Energy had actually identified a "most likely" supplier or set of suppliers. We thought that their basic position was that there were a number of potential promising suppliers, none of which necessarily deserved the mantle of most likely.

We believe that the supplier or set of suppliers will largely be determined by the following factors:

- The comparative economic advantage of alternative sites;
- The role of the federal or State governments (or lack of such a role) in negotiating methanol trade agreements;
- The availability of private capital to establish large-scale methanol plants at various overseas locations; and
- The availability of capital in potential supplier countries, and their desire to establish a methanol industry.

In our view, there is enough room for speculation about the last three factors to allow several potential supply scenarios -- with substantively different methanol sources -- to be considered as quite credible. For example:

- If the federal government wanted to step in and influence who the suppliers were to be, it probably would push for South American sites or perhaps turn to Western Australia.
- Some of the Middle Eastern states have both the gas gathering facilities and the capital to pay for a methanol supply infrastructure. In a free market scenario, they probably would play a major supply role.

b) Will the reliance of the United States on methanol as a transportation fuel add or detract from our national energy security?

We believe that a *large scale* methanol fuels program will improve our energy security under the right circumstances. The *degree* of improvement will depend on whether the vehicles are dedicated or fuel flexible, what the fuel of choice is, which countries supply the methanol, and the nature of the methanol market (how much excess capacity is there?). There is potential for a decrease in energy security if the methanol market is very tight (little or no excess capacity) and the suppliers are not secure. Further details may be found in our testimony.

c) Crude oil and gasoline are fungible products. Can this be said for methanol?

The fungibility of crude oil and gasoline -- that is, the ease with which these fuels may be moved from market to market -- arises from the low cost of tanker shipment, the multiplicity of suppliers and users, and the very flexible nature of the trade of these materials. Presumably, crude oil is the more fungible of the two because it can be transformed into multiple products, thus has a wider variety of markets into which it can be sold. Methanol is now somewhat expensive to ship, and the market is less developed, so that it probably can be said to be less fungible than crude oil or gasoline. If a worldwide market for fuel methanol develops, with several suppliers and many users (that is, the fuels market is not dominated by a U.S. program), and large, dedicated, tankers -- thus, cheap shipment -- then methanol will be as fungible as gasoline. Presumably, this will not be the case in the early years of a U.S. program.

d) If we become dependent on methanol as a transportation fuel, can methanol prices be determined by international petroleum product prices or by a cartel similar to OPEC, if not OPEC itself?

Until natural gas use expands several-fold, methanol prices are less likely than oil prices to be determined by a cartel. Natural gas markets are far less developed than oil markets, that is, gas production as a percentage of reserves is much lower than is oil production as a percentage of *its* reserves. Thus, there will be easy entry of new gas suppliers -- and new methanol suppliers -- into existing markets. This should serve to reduce the market power of the dominant suppliers of an early fuel market. Eventually, the market could tighten, but this won't happen for several decades, and it may be delayed still further if substantial new gas reserves are found -- a realistic possibility.

For similar reasons, analysts have assumed that methanol prices will tend to be based more on marginal production costs than on gasoline prices. Their logic is that, if methanol production costs are low in comparison to gasoline prices, high methanol prices would bring in new suppliers who would presumably undercut the old ones to gain market share. This reasoning sounds sensible to OTA. (Note that the same logic does not apply to gasoline prices, because only a few suppliers can add production at low cost in relation to price, and these suppliers are part of OPEC.)

How many years of "market- rather than cartel-determined" methanol prices might this provide to a U.S. methanol fleet? Assuming a strong but not "no holds barred" effort, it probably would take at least a decade and a half for the United States auto fleet to reach a 10 percent methanol share -- a substantial dependency. Unless natural gas use elsewhere in the world were increasing at an unusually rapid pace, this would likely still leave at least a few decades of market-determined methanol prices, with the possibility of a longer period if the pace of gas reserve additions remained strong.

2. What would be the capital investment required to implement the President's Clean Fuels Program?

OTA has not calculated the capital investment requirements of alternative Clean Fuels scenarios. We understand that the Department of Energy has done these calculations.

3. From the standpoint of overall energy efficiency, what is the comparable energy efficiency of an automobile which uses -- a. gasoline; b. methanol derived from natural gas; c. methanol derived from coal; d. compressed natural gas; e. gasohol; f. reformulated gasoline; g. other alternative fuels?

In answering this question, we will treat efficiency as the *fuel* efficiency of the automobile. From the standpoint of the greenhouse effect, one would also need to consider the efficiency of the process by which the fuel is manufacturered from its feedstock.

It is difficult to forecast the relative energy efficiency of different fuels before many of the fuels have entered wide use in the fleet. We cannot know what design choices and tradeoffs will be made by the vehicle manufacturers, yet these are critical to efficiency. Also, we do not know what general vehicle scenarios will unfold. For example, the efficiency of methanol vehicles will depend on whether they are flexible fuel or dedicated (dedicated - more efficient); whether M85 or M100 is used (M100 should be more efficient); what the level of required nitrogen oxide control will be (stringent control standards could limit efficiency); and so forth.

We believe that dedicated M100 methanol, natural gas, and hydrogen vehicles have the *potential* to be significantly more efficient than gasoline vehicles. Methanol and natural gas vehicles could be perhaps 10-15 percent more efficient than gasoline vehicles, though some have claimed efficiency gains as high as 30 percent, and others that the efficiency gains may be less. The source of the fuels is irrelevant to fuel efficiency -- methanol from natural gas is identical to methanol from coal, and the engine will certainly not know the difference (however, if one is concerned about *overall* energy efficiency from the original energy source -- here, natural gas or coal -- then the efficiency depends on the conversion efficiency of natural gas and coal to methanol. Although different available conversion processes have different efficiencies, the vehicle burning methanol derived from natural gas will likely be more energy efficient, in terms of the original energy feedstock, than the one burning methanol from coal, because natural-gas-to-methanol conversion can be expected to be more efficient than coal-to-methanol conversion). A hydrogen vehicle can attain a 20-50 percent gain in *thermal* efficiency over gasoline, but the higher weight of the fuel system will cut down the net gain. Still, an overall efficiency gain of 20 percent over gasoline vehicles may be attainable. Gasohol and reformulated gasoline, assuming the latter is oxygenated with MTBE, may permit a small efficiency gain over gasoline, perhaps a few percent, though the nature of the computerized fuel control system will be important in determining how much efficiency actually changes. Other alternative fuels -- for example, synthetic gasolines made from coal or oil shale -- may be slightly more or less efficient than current gasoline, but most will differ only moderately.

4. The Administration Emphasizes that the President's Clean Fuel Program is limited to nine cities, principally in major transportation corridors. Consequently other State may find the program politically attractive.

c. Would methanol be practical as an alternative fuel in "cold", northern cities. Is there not a problem with starting methanol cars under cold, winter conditions?

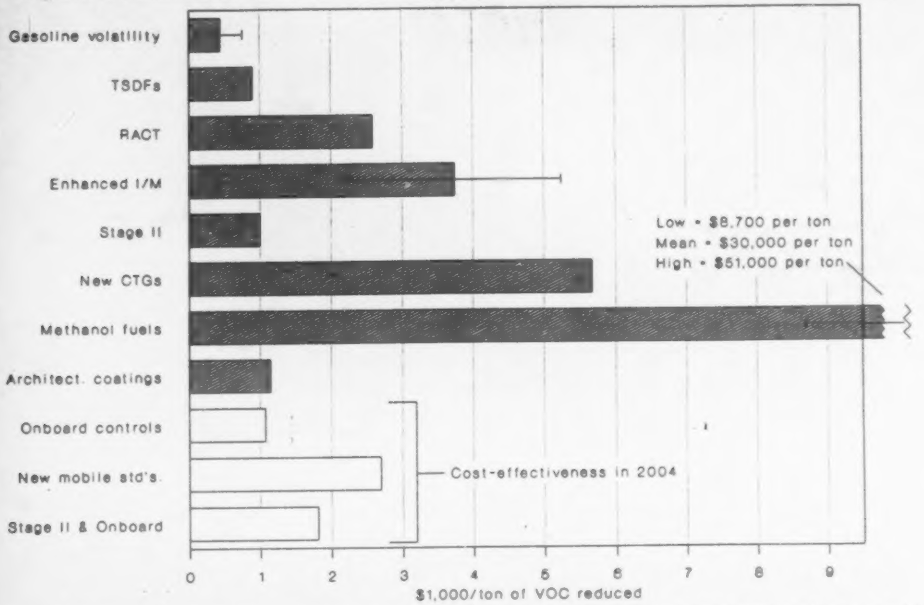
Vehicles using M85, a mixture of 85 percent methanol and 15 percent gasoline should not have significant cold-start problems. Engineers are still trying to develop a cost-effective method for starting vehicles that use 100 percent methanol during the winter.

Senator Murkowski's questions:

We do not have information specific to Alaska's North Slope to be able to answer Senator Murkowski's questions. We note, however, that EPA has compared North Slope methanol costs (delivered to the lower 48) to the delivered costs of methanol from Trinidad, the Middle East, and elsewhere (source: Office of Mobile Sources, U.S. Environmental Protection Agency, "Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel," September 1989). EPA estimated the cost of North Slope methanol to be about $.10/gallon, or 25-30 percent, higher than that of the low-cost suppliers.

OTA agrees with EPA's basic cost calculation methodology, but we disagree with some of EPA's assumptions. In particular, we believe that EPA has tended to understate capital recovery rates. Because methanol plant capital costs would be higher on the North Slope than at the other locations examined by EPA, we suspect that the $.10/gallon differential is probably too low.

Figure 8—Estimated Cost-Effectiveness of VOC Emission Control Methods in 1994 in Nonattainment Cities



The cost-effectiveness of enhanced inspection and maintenance (I/M) programs and new mobile standards include only the cost of VOC control. Since Onboard controls and new mobile standards do not take affect until after 1994, we present the cost-effectiveness in 2004. The thick horizontal bars represent the average cost-effectiveness in nonattainment cities. The thin horizontal lines for gasoline volatility, methanol fuels, and I/M programs represent ranges of uncertainty associated with assumptions we used to estimate total annual costs. The very large uncertainty associated with the methanol fuels is due to the uncertainty of methanol prices relative to gasoline prices. We were unable to estimate cost-effectiveness uncertainty for other control methods. See figure 7 for a description of control methods.

SOURCE: Office of Technology Assessment, 1989.

Donald R. Buist
Director
Automotive Emissions and
Fuel Economy Office
Environmental and Safety
Engineering Staff

Ford Motor Company
The American Road
Dearborn, Michigan 48121

December 19, 1989

The Honorable J. Bennett Johnston
Chairman
United States Senate
Committee on Energy and Natural Resources
Washington, DC 20510-6150

Dear Mr. Chairman:

Enclosed are Ford Motor Company's responses to the Committee's questions regarding the implications of methanol as a transportation fuel. While Ford has been a leader in the area of alternative fuels and we are making substantial efforts to support the President's Clean Air goals for this program, there are significant questions that remain to be answered. We are hopeful that our test programs over the next two years and the Auto/Oil research effort will go a long way to provide many of the answers.

Thank you, again, for the opportunity to speak before the Committee on the subject of alternative fuels. Should your staff have any questions on this subject, please have them contact Mr. Kelly Brown at 313/332-0033.

Sincerely,

D. R. Buist

Enclosure

cc: Mr. J. Bruce

QUESTIONS & ANSWERS

Relative to the
Committee on Energy and Natural Resources
Methanol Hearing of October 17, 1989

QUESTIONS FROM SENATOR JOHNSTON

Practical Considerations

Q1. How do you make the neat methanol powered vehicle start in cold weather? What kind of techniques are there? I understand you might have a separate tank of gasoline, or a bottle of butane in the car.

A1. There are a number of potential solutions, but each has potential for significant negative customer impact in light-duty passenger car or truck applications.

Auxiliary Fuels: The addition of a secondary starting fuel can aid cold start, but:

- It occupies valuable fuel tank space which is needed for the primary fuel. Methanol already suffers from a 40% lower energy content compared to gasoline. Fuels, for a number of reasons, must be stored outside of the engine, passenger or luggage compartments. Thus, driving range will be adversely impacted because of the intrusion of the new tank in the space normally used for basic fuel.
- The air quality gain which might accrue will be affected because of evaporative, running and cold starting with this fuel.
- The second fuel adds to vehicle cost and complexity.
- Customers have shown a reluctance to accept more frequent refueling associated with alternative fuels; this inconvenience factor will be compounded with a second fuel.
- Prior experience with such second fuels/additives have not met with customer acceptance.
- The availability of a second fuel at service outlets will further add to the inconvenience, transition process and customer acceptance barriers for alternative fuels.

The primary reasons for the use of 15% gasoline/85% methanol (M85) fuel, in lieu of a separate starting fuel, are:

- to aid in cold starting without the need for auxiliary heaters or assist systems that add to cost and complexity;
- to provide for flame visibility for fire fighting/recognition;
- to provide for familiar fuel color, odor and taste to reduce the likelihood of accidental ingestion or prolonged exposure;
- to provide for lower aldehyde emissions; and
- to provide for needed lubricity to reduce engine wear.

In comparison to M85, we believe that improved fuels will evolve with the products and technology. The use of pure methanol (M100) will be unlikely because additives for taste, odor, color, flame luminosity, and to provide other commercial fuel characteristics, will be needed. Thus, the "final" fuel may be 95% methanol with 5% other unknown additives; this fuel must be evaluated in marketable products to ascertain the long-term potential air quality benefits of methanol. In summary, there may be opportunities to improve methanol fuel and products once we have developed an adequate data base for current technology and fuels. Ford engineers are designing, developing and testing prototype vehicles to use M85, but it will take two to four more years before a viable product might be ready. M85 fuel makes such vehicles several steps closer to reality. Thus, it is premature to define what the next generation cold-start system or fuel might be when we have yet to complete the first generation baseline.

Q2. **What concerns do you have about garage mechanics working with methanol fuel, especially the problem of absorbing methanol through the skin?**

A2. It is important to note that even gasoline, and other many fuels and solvents can cause severe health problems after prolonged skin contact or aspiration. With respect to methanol, there is published scientific information that it can be absorbed through the skin, although the amount absorbed will depend on the area of the skin surface wetted, the duration of exposure and the integrity of the skin (healthy vs. cut, abraded, etc.). Methanol is a relatively poor solvent for oils and greases and we would anticipate that it would be used less as a solvent that is gasoline today. In the event of probable skin exposure to any solvent or fuel, we would recommend the use of impervious gloves and/or other protective equipment as appropriate. However, the methanol fuel that Ford currently recommends includes 15% gasoline (M85) which provides odor, taste and color which are recognizable as a fuel and deter both skin contact and consumption, and promote washing if contact does occur.

The above not withstanding, the Health Effects Institute (jointly funded by EPA and the U.S. engine and vehicle manufacturers) has recently issued a request for proposals to the scientific community to address the health effects of methanol exposure, both pure methanal and M85. Responses to this request were due at the end of October 1989. One specific area of needed research is a comparison of the dermal and inhalation routes of exposure to methanol. Ford certainly encourages the continuation of research in this area.

Q3. You describe Ford's experience with methanol powered vehicles. Some methanol critics argue that formaldehyde and oxides of nitrogen are increased in methanol cars, compared to gasoline powered cars. How confident are you that you can develop a durable catalytic converter to handle formaldehyde? How long would it be effective before it needed replacement?

A3. Ford has accumulated extensive experience with field demonstrations of research vehicles which are dedicated methanol vehicles (630 vehicles) and some limited experience (about 30 research vehicles) with flexible fuel vehicle (FFV) technology. Only recently have we obtained test facilities and equipment to begin to collect reliable data on emission of formaldehyde. Our aldehyde data is limited to vehicles with less than 35,000-40,000 miles and indicates that formaldehyde is controlled by the catalyst and other control systems in much the same way as unburned hydrocarbons are controlled on gasoline vehicles. We have observed formaldehyde levels in the 30-50 milligrams per mile (mg/m) range, which is below that of pre-catalyst gasoline vehicles, but above that of current gasoline vehicles. The degree to which these emissions can be controlled in-use over the lifetime of the vehicle has not been determined and awaits further development and testing. It would be Ford's design goal to provide a catalyst which requires no replacement during the vehicle's useful life. Preliminary analyses indicate that if formaldehyde can be controlled (by reduction of the level of formaldehyde produced by the engine as well as development of improved catalysts) to the levels we have observed at 35,000-40,000 miles, the vehicles may provide for some reduction in ozone formation in comparison to gasoline.

We have not observed any data to corroborate increases in oxides of nitrogen (NO_x) with methanol and, in fact, our first 40-car experimental fleet (1981) was calibrated to meet a program goal of 0.4 NO_x. The vehicles have successfully met this goal, even at 50K. Many questions which have been raised on this point erroneously cite the 1983 dedicated Ford Escort vehicles as evidence -- these cars were designed and adjusted to meet a higher NO_x standard (0.7 NO_x) than that currently in effect in California. These vehicles continue to perform as intended. The initial fleet of 30 Crown Victorias was built as part of a Canadian program with a NO_x emission goal of 1.0 gm/m. Again, these vehicles perform as intended.

Costs

Q4. How much more expensive do you think a methanol powered, flexible fuel vehicle will be for the consumer than a gasoline powered car? What kind of incentive would the consumer need? What's the CAFE credit worth to the manufacturer under the Sharp-Rockefeller Act?

A4. Definitive estimates of customer costs cannot be assessed until the production design has been more fully developed. In a letter sent to EPA on September 26, 1989, (Attachment I) Ford clarifies it's 1985 preliminary assessments of potential menthol/vehicle costs. These estimates may be too low because they assumed no unique emission controls and no unusual solutions to the remaining technical problems -- recent information indicates that these assumptions may be invalid.

Governmental incentives for consumers may be needed to overcome market resistance to a new product and fuel. Our initial customer surveys indicate that concern for new, more complex technology tends to make them wait several years before purchase for the products to build a favorable reputation. Secondly, concern for non-competitive fuel prices, inconvenient availability or unfamiliar characteristics would add to resistance to use the methanol. Thus, state sales tax forgiveness and incentives to ensure cost competitive available fuel may be needed to overcome early program resistance.

The CAFE benefit is useful in that it provides a compliance cushion to avoid the need for costly, disruptive and uncertain market incentives or sales restrictions if market shifts cause our CAFE level to approach or fall below planned levels. However, if the CAFE level of the manufacturer is well above the standard, they may not have any benefit. Because the CAFE benefit provides value for actions which would be avoided if unique compliance problems occur, it is not possible to quantify the value.

Q.5 **EPA claims that you will be able to produce a neat methanol powered car that costs no more than a gasoline car, citing your testimony before Congress as a reference.**

(a) Can you do it?

(b) EPA also indicates that an optimized, dedicated methanol powered vehicle could be up to 30% more efficient than a future gasoline car. OTA says the figure is more like 10-15% if the car is mass-produced and designed for maximum consumer acceptance. What is your view?

A5. (a) The answer to this question is provided in response to question 4 and contained in Attachment I. Again, we do not believe that even dedicated M85 vehicles are possible in the near-term (as has been suggested by EPA) and, in the longer term, only if the fuel is readily available and competitive nationwide. Dedicated vehicles likely will not be cheaper than FFVs. We believe that M100 fuel is unlikely, but some new fuel with other additives may evolve which is more beneficial environmentally.

(b) Optimized FFVs and dedicated vehicles can be designed which would take advantage of the higher octane, increased efficiency and leaner mixtures which are possible with this fuel. On FFVs, this would degrade driveability and emissions control when operated on gasoline and provide-a market impediment unless methanol were readily available nationwide and cost competitive. For both dedicated and flexible fuel vehicles, such engine and vehicle changes would increase costs, tend to make NO_x emission control more difficult, and eliminate one of the potential incentives to use the fuel -- more performance.

The OTA estimates appear closer to that which may be theoretically possible in the longer term, if the fuel is available and competitive and the products are desirable in the marketplace.

Q6. You say you are reaching the technical limit of what can be done at the automobile tailpipe. Don't significant amounts of hydrocarbons come from evaporation of gasoline from fuel tanks, engines, refueling, starting and stopping engines? Should we be trying to expand the environmental regulation to look at these sources? Is it technologically feasible to reduce these sources of ozone?

A6. All of the sources of evaporative emission hydrocarbons that you referenced are currently controlled on today's automobiles. Evaporative emissions have been controlled on automobiles since 1972; however, in recent years the formulation of gasoline has changed such that it's volatility (the ease with which it evaporates) has increased sharply, primarily during the early 1980's. This has caused fuel evaporation to rise to a point where it exceeds the capacity of the vehicle evaporative emissions system to contain all of the vapors generated during summer time operation. Ford and other auto companies, with general agreement from the oil industry, have long since stated that the control of these emissions far outweigh many other automotive related strategies such as further tightening of tailpipe emissions and the control of refueling vapor emissions. Eliminating these excess evaporative and running loss emissions either by returning fuel volatility to its previous level (9.0 lbs. RVP) or by upgrading the evaporative emissions control systems on new motor vehicles, or a combination of both, will eliminate a total of 25% of the hydrocarbons in the air of a typical city. By comparison, refueling emissions will eliminate on average less than 1% of the hydrocarbon emissions in the city. By comparison, further tightening of tailpipe emissions, as contained in S1630, will reduce ambient hydrocarbon levels by less than 1%. Even the so called tier II emission standard in S1630 would only reduce ambient hydrocarbons by less than 1% as compared to todays levels. (see Attachment II)

Q7. You state that widespread availability of alternative fuels is key to the success of a clean fuels program. You also strongly support the House Subcommittee amendment that would only require manufacturers to certify that they are capable of producing clean fuel cars. How does that certification guarantee the availability of clean fuels?

A9. Neither a sales mandate nor any other vehicle manufacturer requirement or action can assure the availability of the fuel -- that is the responsibility of the states and fuel suppliers. The most appropriate actions to encourage alternative fuel vehicles should be market based -- to encourage interest in and purchase of these vehicles and provide an incentive for the customer to use M85 instead of gasoline.

In order to "certify" that Ford would have sufficient capacity to produce, distribute and offer sufficient number of clean fuel vehicles, considerable design and development work is required up front to take a concept, like the FFV, past the concept stage to high-volume production. Once a decision is made to move to high-volume production, a manufacturer must begin a lengthy and complicated series of development, evaluation and verification programs to be able to produce, distribute and release for sale a vehicle. The required tasks would be the same no matter whether the ultimate level of sales is 100,000 vehicles, one vehicle, or none at all.

Development Phase: During this phase, a manufacturer is required to commit substantial engineering and financial resources to confirm the feasibility of the concept design. Some of the key tasks include:

- Building design-aid bucks to evaluate how new or revised components can be packaged to fit in the vehicle.
- Building development prototypes. These vehicles will be used in laboratory and field tests to determine how the design will perform at high mileage and gather preliminary emissions data.
- Working with suppliers to develop design parameters and set quality targets for producing the new design.
- Identifying and implementing weight-reduction actions to avoid potential fuel economy losses.

Evaluation & Verification Phases: Some of the key tasks in these phases include:

- Evaluating and selecting production suppliers for the various components.
- Building verification prototype vehicles. These custom-made vehicles require retrofitting prototype build facilities to accommodate the revised designs.
- Revising designs and/or manufacturing processes, as appropriate, based on the results of laboratory and field testing or prototypes. These tests are run under a variety of climatic conditions, including cold weather, hot weather and altitude.
- Preparing design blueprints for suppliers.
- Preparing owner's, service and repair manuals.
- Conducting research to help position vehicle in the market.
- Providing long-lead funds to component suppliers. At this time, the manufacturer would have to agree to buy a minimum number of components or be subject to contingent liabilities.
- Funding suppliers to deliver and install appropriate tooling and fixtures at the assembly facilities.
- Upgrading of all of the test facilities to include changes in fuel and/or new test equipment to handle a new fuel or technology.
- Training production employees in the new assembly processes.

Federal Certification Programs: Considerable resources also would be required to conduct mandated certification testing to determine compliance with emissions, safety and other federal regulations.

- Assuming ten separate models are required to meet the Ford's allocation in the alternative fuels legislation, 30 emissions durability vehicles, 24 emissions data vehicles and 36 fuel economy vehicles would be needed at a cost of about $20 million.
- Extensive testing also would be required to demonstrate compliance with safety requirements, such as occupant safety and fuel system integrity.

Q8. Has Ford Motor Co. made the decision that the future fuel to displace gasoline will be methanol?

A8. For high-volume production applications, methanol appears most likely to be an alternative to gasoline and diversify our energy dependence. Whether it can substantially replace gasoline is speculative. Other fuels hold promise, but may have only limited or niche applications. For example, ethanol provides similar benefits as methanol, but is far more costly. Natural gas is both cheap and available, but high-pressure compressors are needed and its lower energy per unit of storage space may limit it to larger, delivery/transit type vehicles in large cities. Propane/LPG has several benefits in storage, pressure and volume, but is limited in its supply (as it is a by-product of petroleum refining/extraction). Both gaseous fuels may have problems meeting current or future NO_x standards.

Ultimately, it is the market that will make the decision as to which fuel or fuels will displace gasoline. For its part, Ford will continue research, evaluation and demonstration of each of these fuels to identify and respond to these market interests.

Q9. Your testimony referred to corrosive effects of methanol. Could you explain the specifics and the problems each kind causes?

A9. Methanol is a conductive liquid and causes corrosion of some metals; this is aggravated in some cases if water is present. Generally, stainless steel, nickel coatings, plastics or other materials must be used for fuel tanks and lines. Unique engine oil additives are also required -- we are working with the oil industry to develop and test these new products. As a modest solvent, it dissolves some glues and softens some types of flexible lines, gaskets and diaphragms. New or different formulations of chemicals are needed to preclude these problems. Such efforts are underway.

Q10. What grade of gasoline does Ford recommend for each type of engine Ford produces for the U.S. fleet?

A10. All of Ford's 1990 gasoline powered products call for regular, unleaded gasoline. Ford does offer one heavy duty truck option which operates on propane.

Q11. Do octane requirements increase for a given engine over time? Please explain. Are there additives available to add to gasoline to remedy any such problems? How costly are these solutions?

A11. Octane requirements do increase over time -- this fact is considered in the development process to ensure that regular unleaded fuel will be satisfactory for the useful life of a properly maintained vehicle. Octane requirements tend to increase as deposits build up in the engine. We are aware of over the counter additives, but do not recommend their use, nor track their costs. First, it is not possible nor are there federal agencies in a position to monitor the quality, appropriateness or effectiveness of these additives.

Second, if spark knock is encountered, it is likely caused by poor tune-up, malfunction or unusual operating conditions. In certain cases, In certain cases, premium fuel may be used temporarily if vehicles encounter knock caused by severe operating conditions or injector fouling (many premium fuels have higher detergent levels which can correct such conditions). Accordingly, we prefer that customers correct the problem or address the conditions rather than cover it up with an octane enhancer.

Q12. Can the addition of MTBE, ETBE, or any other oxygenate to gasoline adversely affect the performance, durability, maintenance schedule, etc., of any Ford auto?

A12. In general, properly formulated additives do not cause problems for Ford vehicles.

QUESTIONS FROM SENATOR McCLURE

Q1. What would be the capital investment (in production facilities, vehicles, refueling outlets, etc.) required to implement the President's Clean Fuels Program,
(a) if methanol were the fuel of choice?
(b) if natural gas were the fuel of choice?
(c) if reformulated gasoline were the fuel of choice?
(d) and for other feasible alternative fuels?

A1. Ford is unable to provide investment costs, primarily because the vehicle hardware and tooling requirements for production applications have not been defined. As outlined in the previous questions, we have a great deal of testing and evaluation work remaining. Similarly, we have not defined any vehicle or engine requirements for other alternative fuels. While methanol has been the focus of our recent efforts, we are continuing to conduct CNG research to determine possible engine, emission control system and vehicle changes which might be required to meet emissions, safety and customer needs. With respect to reformulated gasoline, there is no definition for such a fuel to replace unleaded gasoline but goals have been defined -- lower aromatics, olefins, volatility and benzene. We believe work on such a fuel holds great promise but that work is just beginning. With respect to the investments required for fuel production and retail outlets, we defer to the fuel industry and supplier networks for such estimates.

Q2. You stated that the CNG vehicles would be more costly than FFV methanol vehicles. Would you explain the reasons for that conclusion?

A2. We believe that CNG vehicles should be more costly than FFVs because of the following requirements:

- Unique, high-pressure (2,500-3,000 psi) fuel tanks;
- More fuel storage space;

- High compression engines with new calibrations to provide improvements in performance and driving range;
- New fuel mixers and fuel handling systems, with high-pressure fittings; and
- Undefined emission controls to meet current and pending standards (NO_x is of particular concern).

Q3. What is the potential driving range difference between CNG and methanol vehicles using current technology? How would that differ between dual-/flexible-fuel and dedicated vehicles?

A3. Dual-fuel CNG vehicle driving range would be roughly 20-25% that of a comparable gasoline vehicle for the same volume of fuel (i.e., a loss of 75-80%). If more tank space is added in the trunk, for example, and the vehicle optimized and dedicated to CNG, the driving range would be about 30% to 50% that of a gasoline vehicle (i.e., 50-70% loss).

For an M85 FFV, the driving range is roughly 60% that of the corresponding gasoline vehicle (i.e., a 40% loss). For an optimized dedicated vehicle, it may be possible to achieve driving ranges 65-70% that of the gasoline vehicle. If other space is found for fuel storage, as considered above for CNG, further improvements are theoretically possible.

However, it is crucial to note that the addition of substantial amounts of fuel storage space is not practical because it reduces the vehicle's utilitarian value and increases weight. For large truck applications, some sacrifices for added tank space may be possible.

Attachment I

Environmental and Safety
Engineering Staff
Ford Motor Company

The American Road
Dearborn, Michigan 48121

September 26, 1989

Mr. Eugene Durman
Policy Office
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Durman:

During our September 6, 1989 discussion on alternative fuel vehicles, you requested clarification of Ford's statements regarding the estimated complexity and customer cost of both flexible and dedicated methanol vehicles in comparison to a gasoline vehicle. This information is provided in response to that request.

In conjunction with Ford's 1985 efforts toward preparation of thirty research and demonstration Crown Victoria FFV's, designed to operate on M85, E85 or gasoline, our engineers estimated that the incremental cost to the customer of the FFV might be approximately $150 to $300 at full production volumes (100,000 to 200,000 units). This assumed that all technical issues would be resolved inexpensively, existing emission control technology could be employed, engine optimization would equally favor each of the fuels (methanol, ethanol and gasoline), and all open issues had been identified.

Our current estimate of the eighteen key components which must be changed to produce an FFV are listed in the attachment. However, new projections of customer costs for the FFV feature will not be available for several years, pending the completion of new development work and feedback from field demonstration programs. At a minimum, some of the more recent initiatives for stringent formaldehyde control, better understanding of changes needed in our test and evaluation procedures, and new insight into the actions needed for resolution of the technical problems, can be expected to increase the cost of an FFV.

"Fully optimized, dedicated" methanol vehicles have been considered by many researchers to be the logical goal of an alternative fuel program. In part, this goal has been sought because the engine and vehicle can be modified to take greater advantage of the fuel's unique properties (high octane and lean burn) to achieve fuel economy near to that of gasoline vehicles. It has been our belief that the potential customer cost of M85 dedicated vehicles will be about the same as that of an FFV. In comparison to an FFV, all of the changes in materials, injectors, cold start system, unique emission controls, spark plugs, etc., required for an FFV are needed for the dedicated vehicle, with the major exception of the optical fuel sensor. Offsetting the deletion of the sensor will be several cost additions to produce the "fully optimized" M85 vehicle:

- Higher compression head/pistons
- Strengthened crank and/or bearings
- Possible unique catalyst and EGO sensor

The use of M85 fuel, or a methanol fuel providing similar characteristics, is crucial to the cost effectiveness of the above estimates. This fuel provides sufficient volatility and hydrocarbons to facilitate cold start at temperatures normally encountered in the U.S. In addition, the 15% gasoline provides flame visibility for fire fighting and recognition. M85 also has color, taste and odor that deter accidental ingestion and prolonged skin contact. This fuel also has lubrication qualities. An additive, which may replace the gasoline component of M85, is likely to evolve concurrent with efforts to improve commercial acceptability, reduce reactivity and lower costs of the final product. We support such efforts provided our key concerns are addressed -- those concerns being the preservation of the flame visibility, fuel identification and satisfactory enhancement of cold start.

To achieve appropriate cold start characteristics with M100 would require major engine and/or vehicle modifications with significant cost penalties. Typical considerations are secondary cold start fuels with separate storage, supply and control requirements, manifold/fuel heaters with dual battery (24-volt starting system) or other changes to the intake manifold and fuel pre-treatment systems. Previous Ford development work was unable to identify any practical system that would package and function in light duty applications. Therefore, we believe that a dedicated, M100 vehicle, even if practical for light duty applications, will exceed the cost of either M85 option by a substantial margin. Even if neat methanol is viable, it will require additives, at a minimum, for odor, color and taste to avoid misuse -- these additives may impact vehicle and emission characteristics.

Should you have any questions on this information, please contact me.

Sincerely,

David L. Kulp
Manager, Fuel Economy
Planning & Compliance

cc: Mr. R. Wilson

FLEXIBLE FUEL VEHICLE

MAJOR COMPONENTS UNIQUE FROM GASOLINE VEHICLE

- Fuel system
  - Add optic fuel sensor
  - Redesign fuel injectors
  - Redesign fuel tank *
  - Redesign fuel filler pipe and restrictor
  - Redesign fuel rail
  - Redesign fuel pump
  - Upgrade fuel system materials, as needed
- Add cold start system
- Modify engine electronic control processor (computer)
- Add fuel sensor readout *
- Revised spark plugs
- Redesign vehicle wiring
- Redesign intake manifold
- Redesign/relocate catalytic converter *
- Redesign piston rings *
- Redesign evaporative emission control system *
- Modify engine oil
- Modify transmission calibration *

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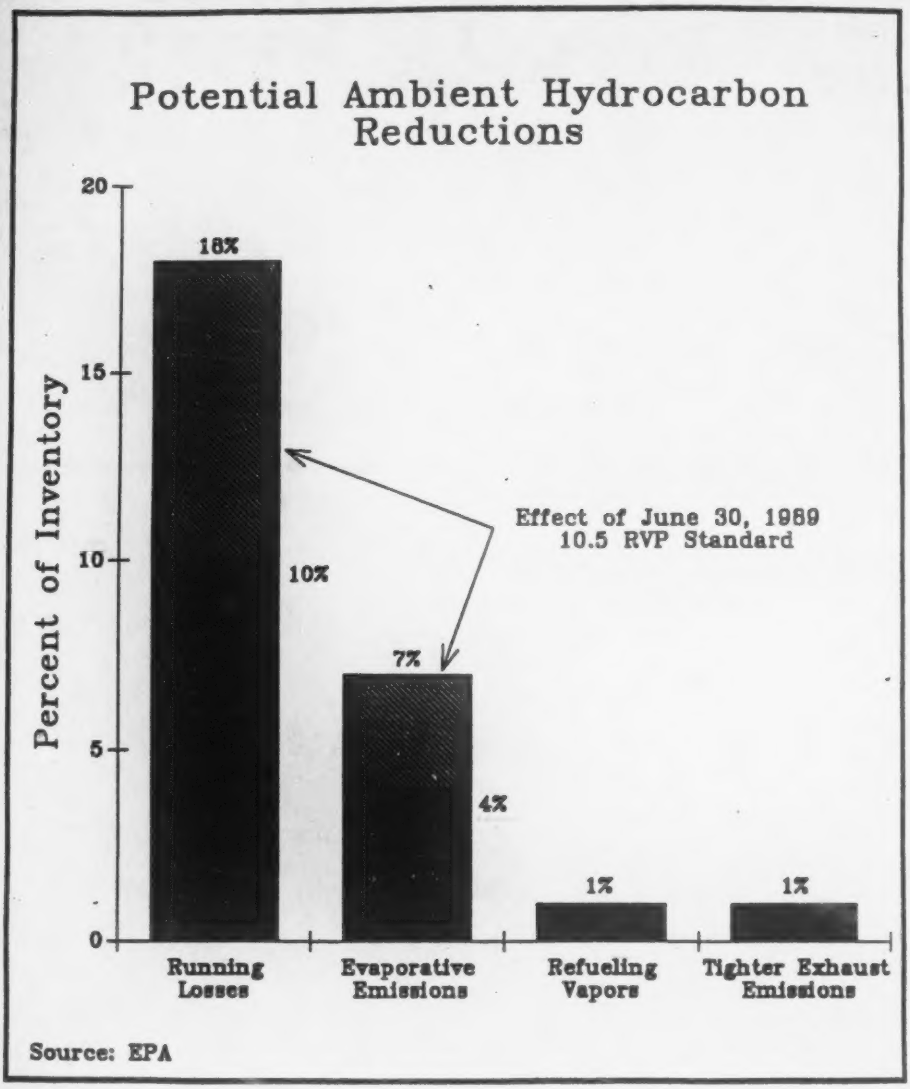
* Not required for all applications.

Attachment II



Source: EPA

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Theodore R. Eck
Chief Economist

November 20, 1989

Mr. Jim Bruce
Dirksen Senate Office Building
SD-364
1st & Constitution Avenue, N.E.
Washington, D.C. 20510

Dear Jim:

Attached are my responses to the questions transmitted by Senator J. Bennett Johnston in his letter to me dated October 30, 1989.

The questions followed my appearance at the hearing of the Committee on Energy and Natural Resources on October 17, 1989 concerning the implications of a switch to methanol as a transportation fuel.

Sincerely,

T. R. Eck
Mail Code 2905A

Attachments

Questions from Senator J. Bennett Johnston

Costs

1. In its special report on methanol, entitled "Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel", dated September, 1989, EPA cited these costs for methanol:

Production: 30 cents per gallon
Ocean transportation: 5 cents
Long range and local distribution: 3 cents
Markup: 5-7 cents
Taxes: 12 cents

The total is 55-57 cents per gallon or $1.05 - 1.09 gasoline equivalent price.

Where do you disagree with EPA on the likely future cost of methanol?

Answer

Amoco's estimates of methanol costs are compared with EPA's estimates in the following table:

	Cents Per Gallon	
	Amoco Estimate	EPA Estimate
Production	40-45 (Middle East)	30
Ocean transportation	4 (Middle East to East Coast)	5 (Caribbean to West Coast)
Long range and Local Distribution	8 (min.)	3
Dealer Mark-up	8-10 (min.)	5-7
Taxes	12*	12*
Total	72-79	55-57
Gasoline Equivalent	144-158	105-109

*1/2 the tax on gasoline if on a BTU-equivalent basis. Sales tax will be a percentage of the pump price.

As I indicated in my testimony, the EPA estimates assume "cluster" plants four times larger than current world-scale plants and include returns on capital far lower than would encourage the private sector to risk building such plants. These optimistic assumptions on plant size and expected return understate methanol price by 10 to 15 cents per gallon, or about 20 to 30 cents per gallon of gasoline equivalent. Remote natural gas prices of 50 cents to $1.00 per million BTUs were assumed by the EPA and we know that gas prices to big industrial projects in some so-called remote locations already exceed that range. Areas probably can be found where gas prices currently are in the range estimated by EPA, but the key issue is the level of prices that can be negotiated over the life of a plant and for future plants. Additional information on production costs is given in the answer to Question 16.

We calculate that distribution costs would be, at a minimum, 8 cents per gallon of methanol. These costs include tankage, terminalling costs, trucking, and marketing costs including capital. They apply to short distances from coastal areas; longer distances would require rail or barge transportation to local terminals as well as trucking, and costs would be higher.

The EPA has assumed that dealer mark-up on methanol would be 50 to 70 percent of the mark-up on gasoline. It is more likely that the mark-up will be closer to that for gasoline since many of the dealers' costs (pumping, storage, filling time as related to driveway congestion) are volume related.

Finally, EPA has used a factor of 1.9 to convert methanol to a gasoline equivalent basis. For flexible-fueled vehicles designed to burn regular gasoline and methanol, we believe the factor should be 2.0, which is the ratio of the BTU content per gallon of gasoline to that of methanol. In an alternative fuels program based on methanol, flexible-fueled vehicles would be needed for many years, because there would be no nationwide distribution system for methanol, and vehicles would have to be developed which would start in cold weather on M100 fuel.

Reformulated Gasoline

2. You say that the auto companies and oil companies will join in a scientific study to compare reformulated gasoline with methanol in dual-fueled vehicles.

a) Are you studying the first generation reformulated gasoline that is already on the market in California or are you looking at second generation versions of reformulated gasoline?

b) Does your company have a reformulated gasoline in the lab that can match M85 emissions?

c) When might you have such a gasoline? How much more would it cost?

d) Would an advanced reformulated gasoline likely reduce the yield of gasoline from each barrel of oil, thereby increasing oil imports?

e) EPA asserts that the U.S. will have to meet its incremental gasoline demand in the future from foreign sources due to environmental and siting problems for refineries. Do you agree?

Answer

a) There will be two phases to the program. The initial phase will test various types of reformulated gasoline and methanol fuels in prototype vehicles. The reformulated gasolines will be made by varying aromatics, olefins, oxygenate levels, and other properties. The gasoline now on the market in California falls within the range. The second phase, to be started in 1990, will conduct research on advanced technology alternative fuel-powered and gasoline-powered vehicles.

b) The test program will determine what types of reformulated gasoline can be cost effective with methanol fuels and other alternative fuels for controlling emissions.

c) Reformulated gasoline can be produced now just by changes in blending, but in small quantities. Arco has produced a reformulated gasoline in California to be used in older cars. Large volumes of reformulated gasoline will require significant changes in refineries and will cost more than conventional gasoline, possibly several cents per gallon more. These questions are being addressed, on industry average terms, in the joint program.

d) Until the Auto/Oil test program is completed, we will not know exactly what processing changes in refineries will be required and what the yield per barrel will be. However, we believe that the yield differences between conventional and reformulated gasoline are likely to be small.

e) Amoco's forecasts out to the year 2000 indicate that most of the increase in gasoline that may be required for the U.S. market will be produced from incremental expansions of U.S. refineries. Capacity probably will be added at existing sites because of environmental constraints to building new "grass roots" refineries.

Toxicity

3. How would gasoline stations have to change their equipment to store methanol?

Would they have to install double walled tanks underground?

Is that commonly done now anyway?

Answer

Storage of methanol would require new storage tanks, lines, and dispensing equipment because of the additional volume and the corrosive effects of methanol. Existing materials are not compatible with methanol; stainless steel might be required. This is true for above ground storage tanks and piping at terminals, in addition to service station facilities. Reformulated gasoline would be compatible with existing equipment and facilities.

Amoco would envision the use of double-walled underground storage tanks to provide secondary containment. This choice would be based on prudent risk management, given the toxicity of methanol and its miscibility with water. Double-walled underground storage tanks are not routinely used by Amoco for gasoline.

Questions from Senator Metzenbaum

1. You seem optimistic that a yet undeveloped "reformulated gasoline" will some day achieve the same clean air results as methanol.

a) How soon do you predict this to occur?

b) How much will it cost per gallon?

c) How much will it cost per vehicle for modifications?

Answer

Reformulated gasoline represents a realistic extension of an on-going process of environmentally-oriented gasoline improvement that started years ago with the phasing out of lead, the employment of improved detergents, modification of the fuel distillation range, increase in alkylate content, and the advent of oxygenated components like MTBE. Volatility reduction is the latest step in this process of continual reformulation. The reductions in tailpipe emissions resulting from these gasoline improvements in combination with the addition of catalytic converters and other modifications to vehicles are demonstrated by emission tests on actual cars on the road today. The clean air results of methanol are hypothetical; they are based upon unproven designs for vehicles, optimistic and unproven assumptions about emission levels from these vehicles, and computer modeling of the effects. Methanol vehicles are expected to emit more formaldehyde, a potential carcinogen, than gasoline engines.

The great advantage of reformulated gasoline over the more exotic alternatives is its potential application to the entire automobile fleet. No vehicle modifications are required to use it; motorists need not scrap their cars and buy new ones. The reformulated gasoline produced by Arco was designed specifically for older cars without sophisticated emission controls.

Some of the changes which have been proposed to gasoline in addition to lower volatility are lower sulfur, olefins, aromatics and end point, and higher oxygenate level. These changes and their relative costs are discussed in more detail in Question 4.

2. Is gasoline containing aromatics or its combustion products corrosive to automobile parts?

Answer

Gasoline is non-corrosive to the automobile engine, gasoline tank, and fuel system. The primary products of combustion are carbon dioxide and water; cold and stopped engines are protected from water corrosion by inhibitors in the motor oil.

3. You say in your prepared testimony that Amoco would have to take "extraordinary measures to prevent contamination of groundwater and water bodies from methanol spills, adding to the transportation and storage costs."

a) Won't methanol dilute to safe levels quickly if it leaked out of tanks or spilled on the ocean or inland waters? Please compare with gasoline and crude oil spills of the same size.

b) Couldn't cheap dyes be added to warn users of well water of leaks from underground storage?

c) Aren't there great dangers of chemical pneumonia and death for persons ingesting gasoline from syphoning or children accidentally drinking it?

Answer

a) Although methanol would be diluted if it came in contact with a water supply, the acute toxicity must be recognized--as well as the inability to contain and remove the methanol from the water. By ingestion, the human lethal dose is reported to be approximately one teaspoon in a small child and one ounce in an adult (Litovitz, 1988). Blindness may occur at less than half that amount. By skin absorption, blindness has been reported following a single exposure to methanol-soaked clothing. Acute poisoning from methanol occurs in three stages (Clary, 1988): immediately following ingestion mild narcotic effects may occur, a latency period of 12-24 hours follows with no symptoms, finally serious and possibly irreversible side effects occur - including blindness and possibly death. Because the first stage effects may not be immediately attributed to methanol, treatment may be delayed until stage three symptoms present themselves.

b) It is potentially feasible that a dye or an odor indicator could be added to methanol to warn users of well water of leaks. The effectiveness of the indicator upon dilution would need to be thoroughly considered, since it would be present at a low concentration even before dilution. Once the methanol gets in the underground water supply, there is no easy way to get it out, and the supply may be unusable.

c) Yes, there are dangers of chemical pneumonia and death for persons ingesting or aspirating gasoline. However, volume for volume, methanol presents a much greater toxicity concern than gasoline in that ingestion of as little as one ounce of methanol can be lethal.

References

Clary, J., A critical review of the toxicity of methanol fuel, Proceedings of the Methanol Health and Safety Workshop, South Coast Air Quality Management District, Los Angeles, CA. 1988.

Litovitz, T., Acute exposure to methanol in fuels: a prediction of ingestion and incidence of toxicity, Proceedings of the Methanol Health and Safety Workshop, South Coast Air Quality Management District, Los Angeles, CA. 1988.

4. You say that some measures to improve gasoline can be done inexpensively, while others are expensive.

a) What are the inexpensive measures and how much improvement does it get you?

b) What are the costly measures? Please break down these costs into elements.

c) What will be the total cost for developing a new gasoline to meet EPA's air quality goals?

d) What will it cost motorists at the pump? Will the yield of gasoline per barrel of oil be lower?

e) What will refiners do with the benzene, olefins, other aromatics, and butane that must be removed from reformulated gasoline to clean the air?

Answer

a,b) None of the changes to gasoline will be without cost, but reducing sulfur content, volatility, and benzene can be accomplished more readily and at less cost than, say, reducing total aromatics, olefins, and distillation end-point. The cost depends on the degree by which each property is changed. We don't yet know what the trade-offs are, and we're hoping that the knowledge to be gained from the Auto/Oil research program will enable us to determine the relative cost-effectiveness of various reformulations with both existing vehicles and future models.

c) Until the scientific and engineering studies are further along, the total cost for developing a new gasoline cannot be estimated.

d,e) Whether there are overall gasoline yield losses will depend on the process choices: for example, butane displaced because of volatility lowering might be converted to MTBE or alkylate and returned to the gasoline pool. Benzene, olefins, and aromatics may be transformed chemically to other hydrocarbons rather than removed.

5. What are the octane requirements for the fleet of 1989 Model Year cars on the road in the U.S.? For all cars on the road today? Please give percentages for each octane number response.

Answer

Coordinating Research Council, Inc. (CRC) has not reported the octane requirement of 1989 model cars and the report will not be publicly available until about June 1990. Also, CRC reports the octane number requirements of new model year vehicles (cars and light trucks) and does not calculate the octane requirements of the in-use fleet.

For the model years from 1978 through 1988, the percentage of vehicles "satisfied" by regular grade, 87 (R+M)/2 octane, as reported by CRC, has varied from 44 percent to 72 percent. The average of the percentages for each of the model years is 56, which is a proxy for the fleet average. The percentage of vehicles satisfied by intermediate grade (89 octane) has ranged from 68 to 88 percent, and the average of the percentages is 78. The percentage of vehicles satisfied by premium (93 octane) has ranged from 91 to 99 and the average is 95.

6. What percentage of Amoco's gasoline sales are for regular unleaded? For midrange unleaded? For premium unleaded? What are the octane ratings of each Amoco grade of fuel?

Answer

Information on Amoco Oil sales by grade is proprietary. In 1989, about half of Amoco's gasoline sales are regular grade.

7. Do all grades of Amoco gasoline contain detergents? Other additives? Please specify what problem each additive attempts to correct.

Answer

All grades of Amoco gasoline contain detergents, which are used to keep the automobile fuel system, including carburetor or fuel injectors, clean. The following additives also are used:

Additive	Purpose
Corrosion Inhibitor	Protects gasoline distribution systems and customers' fuel tanks from corrosion caused by trace amounts of water.
Antioxidant	Helps maintain the storage stability of gasoline.

8. If the volatility of all gasoline today were reduced to 9.0 RVP through removal of butane or related compounds, how much reduction would there be in total reactivity-adjusted VOC and air toxic emissions (including tailpipe, refueling, running losses, hot soak and diurnal, etc.)? How much gasoline volume on a percentage basis would be reduced for summer 9.0 RVP standards?

Answer

The volatility of some gasolines has already been reduced to 10.5 pounds per square inch (psi) or less Reid Vapor Pressure (RVP) by the EPA and to 9.0 psi RVP by the NESCAUM states during the summer period. In order to meet the specification at terminals and service stations during the summer months, refinery output must be adjusted over about a six-month period. This has resulted in a reduction in volatile organic compounds (VOCs) of about 600 thousand tons per year, or about 3 percent, as estimated by EPA's computer model MOBILE4. On a reactivity adjusted basis, the reduction is only about 1 percent. Further reduction to 9.0 psi RVP nationwide during the same period would reduce hydrocarbon emissions from vehicles by another 300 thousand tons, or about half a percent on a reactivity adjusted basis. Both the Auto/Oil program and an API program are measuring individual hydrocarbon emissions so that "reactivity-adjusted" emissions can be determined to give more realistic estimates of potential ozone benefits. We expect results from those programs to be available by the third quarter of 1990.

Toxic air emissions are not expected to be reduced by gasoline volatility reductions since nearly all the reduction is butane, which is non-toxic.

So far, EPA's Phase I RVP reduction plus the reduction to 9.0 RVP in the NESCAUM states has reduced the gasoline pool volume during the affected months by about 4.5 percent. A further reduction to 9.0 RVP nationwide would increase the loss to 6.5 percent. The costs for these reductions are estimated at 2 and 3 cents per gallon, respectively. Eventually, some of the butane rejected from gasoline may be converted to alkylate or MTBE and returned to the gasoline pool, reducing the yield loss and possibly the cost.

9. If, in addition to lowering volatility to 9.0 RVP, the aromatics currently produced at the refinery to enhance octane were not produced, how much reduction in reactivity adjusted VOCs and air toxics would result? (Include same combustion and evaporative emissions listed above). What would be Amoco's dollar losses if it could not use its reformer capacity to increase octane?

Answer

A major goal of the Auto/Oil research program is to measure the effects of aromatics levels in gasoline on vehicle reactive VOC and air toxic emissions so that this question can be answered with some degree of confidence. Preliminary results are expected in the third quarter of 1990.

Tailpipe emissions of benzene have been studied as a function of both the benzene content of the fuel and as a function of the aromatics content. Studies were completed in 1986 by the Coordinating Research Council, which is funded primarily by the Oil and Auto industries. Another study was completed in 1986 by the California Air Resources Board (CARB). These studies gave consistent results. They indicate that vehicle benzene emissions would be reduced in direct proportion to the reduction of benzene in the gasoline, and that for each 10 percent reduction of aromatics in gasoline, exhaust benzene emissions are reduced about 1 percent.

Shutting down reformers would result in a severe economic penalty. Reformers supply large quantities of aromatics for petrochemical feedstocks, and hydrogen for desulfurizing transportation fuels. Aromatics levels in gasoline could be reduced without shutting down reformers, but could not be totally eliminated even if reformers were shut down. Other process units such as catalytic cracking and coking also produce aromatics, and they occur naturally in crude oil.

10. How would each of these modifications affect the yield per barrel of crude, cost of refining, and octane?

Answer

After we obtain results from the Joint Auto/Oil Research and other studies, we will be better prepared to determine processing requirements, their costs, and yield effects.

11. If alcohols were produced from natural gas or agricultural products, combined with a derivative of butane to produce MTBE or ETBE, and mixed 15-17 percent by volume with all gasoline as formulated in questions one and two above:

a) How much reduction in VOC's, air toxics, and CO would result?

b) What would the octane rating of the gasoline be?

c) How much would this reformulated fuel cost at today's prices using:

1. spot priced crude oil and domestic natural gas used for methanol feedstock;

2. spot-priced crude oil and domestically produced ethanol;

3. foreign methanol

d) How much would the 15-17 percent ether additives cost using the above assumptions?

Answer

a) MTBE at 15 percent appears to have no overall impact on VOC emissions. The available data show a slight decrease in exhaust VOCs, but a slight increase in evaporative VOCs and the two effects about cancel each other. However, EPA claims that vehicle NOx emissions increase about 6 percent with use of 15 percent MTBE, and NOx in the atmosphere is also a precursor to ozone formation in urban areas. California has also stated this concern.

Vehicle exhaust CO emissions are reduced with use of 15 percent MTBE in gasoline by about 10 percent for modern technology cars which have good control of the amount of fuel delivered to the engine, and therefore, relatively low CO emissions. For the older cars with poorer control of fuel delivery, the CO emissions are about triple the level of modern technology cars and the reduction of CO due to the leaning effect of 15 percent MTBE is about 25 percent. The net effect for 15 percent MTBE on the mixture of newer and older technology vehicles, representing all cars on the road, is about a 15 percent reduction in exhaust CO. However, that benefit will drop in future years as the higher emission, older vehicles are retired from use.

Some studies of oxygenated gasoline attribute potential ozone reductions to reduced CO emissions but overlook the NOx increases which potentially increase ozone. It is unclear what net ozone benefit or detriment results from oxygenated fuels.

The reduction in vehicle CO emissions which can be achieved by use of 15 percent MTBE, could also be achieved by adjusting the vehicle's fuel system slightly leaner. In addition, adjusting the fuel system would increase fuel economy as cars are brought closer to their optimum operating point, while use of oxygenates decreases miles per gallon efficiency since the oxygen has no fuel value.

Benzene emissions may be reduced with use of 15 percent MTBE because the benzene content of the gasoline pool would be reduced slightly due to the dilution. Formaldehyde, which is a possible carcinogen, appears to be emitted at higher levels with use of any oxygenate. This trade-off between benzene and formaldehyde is being studied in both the Auto/Oil and API research programs.

The above discussion has dealt specifically with effects of MTBE on vehicle emissions. We expect ETBE to have about the same effects as MTBE due to its similar chemical structure. However, we know of no vehicle test results for ETBE. The effects of ETBE on vehicle emissions are currently being studied as part of the API's emissions test program.

b) The octane of gasolines containing oxygenates would be no different from current octanes. If oxygenates were mandated, refiners would maintain current pool octane levels by adjusting other process operations.

c,d) The following table shows the approximate costs of MTBE or ETBE and the cost of adding 15 percent to gasoline, for specific crude oil and natural gas price assumptions:

	U.S. Gulf Coast	
Assumption	Cost of Ether, ¢/gal.	Additional cost of gasoline, ¢/gal.
Current spot priced crude oil and domestic natural gas used for methanol feedstock (50¢ per gallon methanol at Gulf Coast)	75	2.5
Current spot priced crude oil and domestically produced ethanol ($1.20 per gallon ethanol at Gulf Coast)	105	7.0
Current spot priced crude oil and foreign methanol (42¢ per gallon methanol delivered to Gulf Coast)	71	2.0

Note that a maximum of about 13 percent ETBE could be added to gasoline under current EPA regulations, although the calculations are based upon 15 percent. Also note that methanol is a world commodity, and there would be only one price regardless of whether methanol was produced in the United States or offshore. In the table, the differences shown in methanol costs reflect differences in the cost of manufacturing methanol.

12. How much North American natural gas and new infrastructure would be needed today, in 1995, 2000, and 2005 to make sufficient quantities of MTBE to add to all gasoline to oxygenate the gasoline to the maximum extent practical?

Answer

Assuming a level of 7 percent MTBE in all U. S. gasoline in 2000, up to 8.4 billion gallons of MTBE per year would be required. This would require 2.5 billion gallons per year of methanol, or about two of the large "cluster" plants. Currently, the U.S. produces 1 to 2 billion gallons per year of methanol and the world 6 to 7 billion gallons per year. At the present time, it is not cost effective for Amoco to add more than 6 or 7 percent MTBE to gasoline as an octane improver. This could change in the future depending upon how the cost of adding octanes changes.

About 0.2 trillion cubic feet (TCF) per year of natural gas would be required to manufacture the methanol, which is 1 to 2 percent of current U.S. natural gas production. Investment on the order of $10 billion would be required for butane isomerization and dehydrogenation, methanol plants and MTBE plants. Currently, up to 15 percent MTBE can be used in gasoline under EPA regulations. If all gasoline were required to contain this level, the amount of MTBE, methanol and natural gas required would be a little more than doubled. Supply and demand balances for butane indicate there is not nearly enough butane available in the United States, and possibly not enough available worldwide, to supply 15 percent MTBE or ETBE in U.S. gasoline.

13. How much North American cultivated land and new infrastructure would be needed today, in 1995, 2000, and 2005 to produce enough ethyl tertiary butyl ether (ETBE) to add to gasoline to oxygenate the gasoline to the maximum extent practical?

Answer

We will assume that the maximum practical volume of ETBE in gasoline is 12.7 percent. This corresponds to 2.0 weight percent oxygen which is the EPA limit for oxygenates other than MTBE. At 120 billion annual gallons of gasoline in 2000, about 6 billion gallons of ethanol per year would be needed to produce the requisite ETBE.

Corn requirement would be about 2.3 billion bushels or about 30 percent of the present corn crop, and the land requirement would be about 25 million acres. It is almost within the capability of the U.S. farm system to produce this volume of additional corn. About 15 to 25 million acres of farm land are usually set aside each year. Using all the set-aside land and producing the maximum corn possible from all land that could be planted in corn would provide just enough corn and ethanol for the ETBE. This would require annual corn crops of 10.0 to 10.5 billion bushels. For reference, 1989 corn production should be about 7.7 billion bushels while 1988 (with the drought) was only 4.9 billion bushels. If corn yields are low (and 3 of the last 10 years had low yields due to drought, blight, etc.), then a significant shortfall would result which could bring up a tough political question of food vs. fuel.

Ethanol used in motor fuel currently is subsidized through waiver of the federal tax on gasoline containing ethanol. If a similar subsidy were applied to ETBE based upon the ethanol used to manufacture it, the subsidy for 15 billion annual gallons of ETBE would be about $4 billion annually. For comparison, the total federal tax collected for the highway fund is about $15 billion annually.

Finally, about $15 billion would need to be invested in ethanol plants, and another $10 billion in butane conversion and ETBE plants or $25 billion total to provide the necessary ETBE.

14. Is it technologically and economically feasible to design automobiles and fueling infrastructure that significantly reduce refueling, running loss, hot soak and diurnal reactivity adjusted VOC emissions?

Answer

Yes, it is technically feasible to change the design of automobiles and/or the fueling infrastructure to reduce refueling, running loss and evaporative VOC emissions from vehicles. A slight increase in the size of the evaporative emission canister, which is already on all cars, would reduce the evaporative and running loss emissions. In addition, the gasoline volatility reduction which has already occurred during the past "summer" period has resulted in a major VOC reduction estimated by EPA at about 600 thousand tons per year. EPA estimates, probably optimistically, that ozone is being reduced 3-5 percent in urban areas by the VOC reduction.

Refueling controls, either installed on vehicles or Stage II controls at service stations, are technically feasible and have been shown to reduce refueling emissions by about 90 percent. However, full implementation of refueling controls is estimated by EPA to reduce urban ozone by only 1 to 2 percent. On a reactivity-adjusted basis, evaporative and refueling emission controls are only one-third as effective as EPA estimates.

As I discussed in my written testimony, tailpipe emissions of hydrocarbons and carbon monoxide in 1983 and later cars have already been reduced to 5 percent or less of pre-control emissions and will be reduced even more under the standards proposed by President Bush. Running and evaporation losses will be reduced by lowered gasoline RVP and can be reduced further by some design changes in vehicles. Gasoline volatility reductions to 9 psi RVP will cost the country $1.5 billion per year and either onboard auto canisters or service station refueling controls will cost an additional $1 billion per year. The increments of emission reduction are being accomplished at increasingly higher costs, and these costs must be weighed against the potential benefits.

15. Is it possible to adapt the Trans-Alaska oil pipeline facilities to "batch" transport methanol produced on the North Slope to Valdez and store it until loaded on tankers? How much would it cost? What would the cost of a parallel methanol pipeline be?

Answer

Amoco has not studied whether it would be feasible to batch-transport methanol through the Trans-Alaska oil pipeline. We can speculate about some of the changes which might be required, such as complete drying of all the crude oil that enters the line, including the tanks which hold crude oil on the North Slope; changing the seals and gaskets and coating the inside of the pipeline to prevent corrosion and leaks; and possibly redistilling methanol at Valdez to remove contaminants. It is likely that these changes would be prohibitively expensive. The California Fuel Methanol Cost Study had estimated a cost of 52 cents per gallon to move methanol through a new pipeline from the North Slope to Valdez and from Valdez to California by tanker. This very high cost for transporting methanol to markets from Alaska would make it an uneconomical source of methanol.

16. How much would an "economy of scale" methanol plant cost if constructed on the North Slope? Trinidad? Venezuela? Nigeria? Saudi Arabia?

How much would operation and maintenance on those plants and the facilities necessary to transport, store, and load methanol onto tankers cost?

Answer

Amoco Oil Company was a participant in the California Fuel Methanol Cost Study along with other oil companies, the California Energy Commission, the South Coast Air Quality Management District, and other groups. The study was conducted by Bechtel, Inc. Bechtel estimated costs for 10,000 metric tons per day cluster methanol plants (approximately 1.2 billion gallons per year), about four times the capacity of the world's current largest plant, and equivalent to 20 percent of present world chemical methanol production. As indicated in my testimony, Amoco is unsure whether anyone would risk building a plant this large, considering all the uncertainties involved. Capital and operating costs quoted in the study for plants at several locations are summarized below:

	Costs, Mid-1988 Dollars, per Plant		
	Caribbean	Middle East	Prudhoe Bay
Investments, Millions	1000	1100	1500
Annual operating costs, Millions	68	82	110

Costs, including those associated with recovery of investment and expressed per gallon of methanol are summarized below:

	Costs, Cents per Gallon of Methanol at Plant Gate		
	Caribbean	Middle East	Prudhoe Bay
Annual capital charges at 25 percent of investment*	22	24	33
Operating Cost	6	7	10
Natural gas at $1.00 per million BTUs**	10	10	10
Corporate overhead cost	2	2	3
Total	40	43	56

*Capital charges including return of capital, return on investment, and foreign, U. S. and state income taxes.

**Each $0.10 per million BTUs decrease or increase in gas prices would decrease or increase methanol price 1 cent per gallon.

The largest plants currently being built in the world are about one-fourth the size of the plants evaluated in the California Fuel Methanol Cost Study. If investors choose to build plants of current size, costs for methanol would be increased by at least 5 cents per gallon because of higher capital and operating costs.

The California Fuel Methanol Cost Study did not specifically evaluate Nigeria as a plant site. A plant built in Nigeria might cost more than one built in the Middle East because of additional infrastructure costs. For remote locations, infrastructure costs, including roads, housing, communications, hospitals, etc., could add up to 100 million dollars to construction costs.

Additionally, the cost to develop the necessary gas fields could almost double the capital investment required. Finally, the EPA assumed that methanol produced at Prudhoe Bay could be transported through the Trans-Alaskan Pipeline and delivered to California for 8 cents per gallon. This assumes that there are insufficient new oil discoveries to fill the pipeline, and overlooks materials compatibility problems where methanol might cause pipeline leaks. The Bechtel study assumed a new pipeline with transportation costs from Prudhoe Bay to California of 52 cents per gallon.

17. At what rates of production is flared or vented natural gas produced in all of the remote locations referred to in EPA's testimony? Given these rates of associated gas production, could each large methanol plant be supplied with enough feedstock to produce consistently at design capacity? For how many years could these plants operate at design levels based on estimates of proven reserves of associated gas for the various locations?

Answer

The following table shows how flaring losses in OPEC countries have decreased since 1978:

	Flaring Losses of Natural Gas, Trillion Cubic Feet		
	1978	1980	1987
Algeria	0.44	0.34	0.22
Indonesia	0.15	0.23	0.13
Iran	1.00	0.33	0.17
Iraq	0.26	0.34	0.18
Kuwait	0.33	0.05	0.02
Libya	0.19	0.16	0.08
Nigeria	0.72	0.83	0.42
Qatar	0.16	0.04	0.00
Saudi Arabia	1.34	1.35	0.07
U.A.E.	0.44	0.34	0.08
Venezuela	0.52	0.08	0.07
Others	0.06	0.08	0.06
Total O.P.E.C.	5.62	4.18	1.50
World Total	7.37	5.85	2.76

According to the OPEC Annual Statistical Bulletin, flaring losses in OPEC countries have decreased from 5.6 trillion cubic feet (TCF) in 1978 to 1.5 TCF in 1987. According to the same source, world flaring losses have decreased from about 7.4 TCF to about 2.8 TCF over the same period. Flaring losses probably will continue to decrease in the future as more gas is reinjected, consumed in industrial projects, or exported. Small quantities of gas in remote areas probably will continue to be flared because of high recovery and transportation costs, but for the same reasons would be impractical for methanol production.

Approximately 0.1 TCF of natural gas per year would be required for each large cluster methanol plant (2.2 TCF over twenty years) and only a few countries are flaring enough gas to sustain such a plant, and possibly not at any one site. Special studies would be required to determine whether there are any sites with sufficient flared gas to sustain a very large methanol plant.

The concept, advanced by EPA, that methanol can be made very cheaply from "throw-away" gas available around the world is not supported by these figures. Methanol plants will be in competition with LNG plants and other uses for gas and will have to pay the competitive market price for gas.

EPA has also stated that reinjected gas could be used to supply methanol plants, but since reinjected gas is recycled gas (the same molecules are circulated through the reservoir over and over again), special studies would be required to determine whether reserves of gas associated with a given reservoir and potential production rates are sufficient to support a plant. In many cases, gas is being reinjected to maintain reservoir pressure and oil production.

18. Mr. Rosenberg testified that "most of the methanol with the exception of what is produced in Alaska, if any, will be imported just as most of the incremental gasoline that is going to meet our increased demand will be imported."

Why will most additional gasoline come from imports?

Answer

Amoco's forecasts show that only a small percentage of the incremental gasoline needed by 2000 will be imported. We project that between now and 2000 U. S. refinery capacity will be expanded incrementally to provide additional gasoline and distillates. The incremental crude oil probably will be imported, however, because U. S. oil production is declining and promising new areas are not being opened for exploration.

19. Will the President's clean air proposal effectively inhibit the ability of new domestic refineries to produce gasoline? Will any other federal or state proposals do so?

Answer

The prospect of diminished demand for the refiners' principal product, gasoline, is the greatest inhibitor to modernization and expansion of existing refineries or construction of new ones. Hence, proposals for alternative fuels and increases in fuel taxes are counter-productive to the national objective of maintaining a strong domestic refining industry. The proposed bargaining away in GATT negotiations of the current import duties on petroleum products would further discourage U.S. refining investments.

WORLD RESOURCES INSTITUTE

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October 31, 1989

The Honorable J. Bennett Johnston
Committee on Energy and Natural Resources
U.S. Senate
Washington, D.C. 20510-5150

Dear Senator Johnston:

Enclosed are my answers to the four questions that you posed after my October 17 testimony on methanol.

> Q1. What is your view of methanol if, as EPA says, there is enough natural gas in the world to use that as a feedstock for the next several decades?
>
> A1. There are two underlying problems with importing methanol made from natural gas. First, the CO_2 emissions per vehicle mile traveled would be about the same for a methanol (made from natural gas) vehicle as they are for a gasoline vehicle. Hence, there would be no greenhouse benefit. This would be a major handicap when viewed against the long-term need to reduce CO_2 emissions by 50-80 percent (EPA's conclusion) and the growing contribution of ground transportation to CO_2 emissions. In this very important respect, pursuing methanol is a dead-end; it is just another fossil fuel -- and not a materially cleaner one at that -- that would not contribute to solving the greenhouse problem and would divert resources away from other, preferable, long-term non-fossil technologies such as electric or hydrogen powered vehicles. Second, most of the world's less expensive, exportable natural gas is in eastern bloc or OPEC countries. I see no national security benefit in changing our energy dependency from oil to methanol.
>
> Q2. You oppose a switch to alcohol fuels and instead advocate de-emphasizing the role of the automobile in daily commuting. Haven't we tried that and pretty much failed?
>
> A2. By no means. In my view we haven't yet begun to explore options to the automobile for commuting. Clearly, our urban areas are becoming progressively more gridlocked. Because of the artificial cheapness of commuting by auto (the security and balance of payments problems of 40% oil imports are certainly not reflected in gasoline prices) we find people traveling by auto many tens of miles to work. Where efficient

public transit is available, e.g. in the Washington area, it is widely used and offers one of the few means of avoiding a total standstill.

If I were in the Congress I would propose legislation to establish a national commission to explore ways of improving transportation efficiency. We need some truly creative thinking on land use planning and transportation. At any rate, an escalating fuel tax would be a good first step to encourage more efficient vehicles and more use of HOVs, commuter buses, and other forms of mass transit that are already available.

Q3. What are the current cost estimates for a hydrogen powered vehicle, as compared to gasoline? Please provide initial and operating costs.

A3. It is not possible at present to provide accurate cost estimates for the initial and operating costs of hydrogen vehicles which are still in the development stage. However, hydrogen made from water at current electricity costs (about $.06 per kwhr) would be about $2.25 per gallon of gasoline equivalent. In their report on solar hydrogen, Ogden and Williams believe that hydrogen costs can be reduced to $1.68 to $2.35 per gallon of gasoline equivalent, comparable to other fuels of the future. They further estimate that total owning and operating costs would be about 20% higher for hydrogen than for gasoline (at $1 per gallon). See page 65 of their report.

Q4. If we discover a cost-effective way of making methanol from biomass why wouldn't that help the global climate change situation -- we would grow additional biomass that would turn CO_2 into oxygen as it grows?

A4. The underlying problem of making methanol from biomass is that photosynthesis is too inefficient (usually less than 1% efficient) and land-intensive. When you combine this low efficiency with the energy losses in cutting, grinding, and converting biomass to methanol you end up with dismal efficiencies of far less than 1 percent. To quantify this, consider replacing 1986 U.S. gasoline, diesel, and jet fuel use with methanol from wood. The only sensible way to produce large amounts of methanol would be via dedicated tree farms: a highly mechanized, agricultural like setup. Assuming 6 tons of dry wood per acre-year (more than 6 times the present productivity of forests) and a 55% conversion efficiency from wood to methanol, one would need an area of about 351 million acres, comparable to our entire area devoted to cropland. All trees now on the land would have to be clear cut. Fast growing trees would be closely planted in rows. They would be irrigated, fertilized, and treated with pesticides, and harvested like corn every 2 to 7 years. These tree farms would be monocultures with essentially no wildlife or recreational value. The total land commitment would be more than the combined area of all the states on the Atlantic coast from Maine to Florida. I don't think this kind of operation makes sense compared with PV cells capturing the sun's energy at 15-30 percent efficiency with few of the impacts of high yield silviculture.

Sincerely,

James J MacKenzie

James J. MacKenzie, Ph.D.
Senior Associate

APPENDIX II

Additional Material Submitted for the Record

AMERICAN METHANOL INSTITUTE

TESTIMONY

UNITED STATES SENATE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

WASHINGTON, D.C.

OCTOBER 17, 1989

American Methanol Institute
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202/554-2850
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Testimony of the American Methanol Institute
to the Senate Energy and Natural Resources Committee

The Status of Methanol as a Source of Clean Alternative Energy

AMI represents a number of companies engaged in the production and trading of methanol both within continental USA and globally. It has been recently formed in order to contribute to the debate on methanol and promote fuel methanol as a source of clean energy in the USA.

The most important fact concerning methanol is that despite recent anti-methanol publicity, there are no showstopping reasons why it should not be widely used as a clean motor fuel. In fact, taking all factors into consideration, it represents the most promising alternative fuel and has the potential to make the most significant contribution to clean air. This conclusion has been reached independently by the AB 234 Committee on Alternative Fuels Policy set up by the California Legislature, the Environmental Protection Agency, and other agencies both federal and state. These bodies are not commercially biased. They gain no kudos either commercial or political from recommending a novel fuel. The reason they recognize the benefits of methanol is that from the six most critical viewpoints it represents the best overall choice for the future. These critical factors are:

Safety
Environment
Air quality
Economics
Energy security and diversity
Engine availability and performance

The AMI does not insist that methanol is perfect; like all fuels it has its drawbacks, but many and varied are the myths, exaggerations, and canards that have been set up deliberately to confuse the general public about methanol. Strong anti-methanol statements are being made by companies having no experience of methanol production, distribution or utilization.

Some of the myths we would like to expose today are:

"*Methanol would increase US dependence on foreign energy/Middle East.*"

There is a huge surplus of natural gas in the world today. Much of it is in friendly countries that do not currently supply the USA with energy. Methanol made from such gas would add diversity (and therefore security) to USA energy sources. There is more than sufficient gas to supply the methanol for our motor fuel needs. Methanol, in the absence of higher fuel economy standards, would not reduce USA import energy bills, but would help reduce our dependence on OPEC and crude oil. To the extent that fuel methanol would be imported, it would replace imported gasoline. It would not therefore jeopardize USA crude oil domestic production.

"Methanol plants are too expensive."

Large scale plants dedicated to USA fuel methanol production would benefit from massive savings in capital per ton-year, lower feedstock costs, operating costs, and transport costs. Such plants would also benefit from the significantly improved technology now being developed. Further, since the plants would be supplying a large, stable, long-term demand, risks, and hence cost of capital, would be correspondingly minimized. The result would be methanol supplied to the USA at a price which would allow it to be cost competitive with gasoline.

"Methanol would involve unacceptable environmental hazards."

The companies belonging to AMI have manufactured many millions of tons of methanol distributed to thousands of customers around the world for decades. Handling methanol is well understood and does not represent a threat to public health and safety. Indeed, studies show that methanol is relatively benign. It is metabolized quickly by many plants and animals, and is already present in small quantities in many natural products. Because of methanol's infinite miscibility with water, a large tanker spill would cause little concern. In the event of an accident the contents of a large super tanker, for example, would rapidly disperse so that even if confined to within one mile from the ship, the methanol concentration would be below 0.01 percent, and so essentially harmless.

"Methanol infrastructure would be too expensive."

It has been shown that fuel methanol can be readily transported through existing pipelines. The costs of storage and distribution facilities have been estimated by the Department of Energy and shown to be reasonable. Exaggerated accounts of infrastructure costs assume a massive swing to methanol fuel, whereas in fact, the President's bill foreshadows a relatively slow transition only to around a 10 percent substitution. At this level the establishment of a methanol infrastructure would not be traumatic and the cost would be cushioned by the fact that the equivalent cost to oil companies of expanding refineries would be avoided.

"Methanol is too toxic for fuel use."

Methanol is already in widespread domestic use both as a 60 percent component of windshield washing fluid, and in neat form as an antifreeze. In neither case are we aware of any particular problem. Ironically those who sell these products seem frequently to be the same companies arguing that fuel methanol is toxic. Nevertheless, we acknowledge that methanol is toxic to humans and accordingly we propose to add a bitter, emetic agent to all fuel methanol so that ingestion would not be practicable.

The above brief comments will, we hope, help to dispel some of the more prevalent methanol myths in circulation. We intend over the next few weeks to deal with further examples.

AMERICAN METHANOL INSTITUTE
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Washington, DC 20026
(202) 554-2850

November 17, 1989

The Honorable J. Bennett Johnston
Chairman, Senate Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510-6150

Dear Senator Johnston:

I have pleasure in submitting on behalf of the American Methanol Institute our answers to the questions you raised concerning our written testimony regarding methanol as a transportation fuel. If any further clarification or details are required by you or your staff, we would be most pleased to help.

Sincerely,

Glyn D. Short
Director, American Methanol Institute

GDS/tle

111789TLE03

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AMI Reply to Questions from Senator J. Bennett Johnston

(1) Cost of Methanol

a) Currently most methanol is sold worldwide for chemical and solvent applications and over the last ten years the price has fluctuated widely. For example in 1988 the world price in reaction to changes in the supply/demand balance approached 60 cpg, whereas in 1989 this price has fallen to less than 30 cpg.

b) The methanol industry is developing ways to handle the market development phase of fuel methanol. For example the California methanol fuel reserve has been established to serve the demonstration programs in that state. The reserve works by requesting methanol producers to nominate a methanol volume at a competitive price that is determined by the California Energy Commission.

c) We have stated in our testimony that widespread use of methanol (corresponding to the 5% car penetration envisaged by the Administration's Bill) would lead to a fuel methanol price competitive with gasoline. This forecast is made up from two elements:

- o The cost of bulk methanol delivered by tanker to a deep water port
- o The cost of delivery to and selling the methanol at a retail fuel outlet

Bulk methanol cost is largely determined by two factors:

- o The cost of natural gas feedstock
- o Capital charges

In reaching our conclusions we have allowed for substantial cost savings relative to chemical methanol stemming from improved methanol technology (allowing lower capital charges), and we assume that long term contracts can be negotiated with gas-rich countries at advantageous prices because of the guaranteed high volume fuel market.

(2) Subsidies

In the longer term, fuel methanol made in large scale plants will be cost competitive with gasoline without subsidy. In an intermediate period when demand is too low to justify building such plants the fuel market will be satisfied by smaller, less economic chemical methanol plants. The price of chemical methanol fluctuates with world demand, so it is possible, during a transition period if methanol price rises considerably, that methanol may be more costly than gasoline. In such a scenario, a dialog between legislators and industry needs to be established in order to explore the several options allowing continued use of methanol fuel in the interests of clean air. In general, we do not advocate granting methanol a subsidy over the long-term. In fact, we do not support any subsidy of alternative fuels, since it forces fuel choices which may not be the best, and may unfairly penalize one fuel with respect to another.

(3) Storage

Underground tanks at service stations may already be suitable for storing methanol if they are made of mild steel or certain grades of fiberglass. If an existing tank is not compatible with methanol it can be given an epoxy coating at a cost of approximately $5000. A number of fuel suppliers in California are already installing methanol compatible storage tanks as part of their normal replacement cycle.

At the present time methanol is widely stored in terminals throughout the world usually in mild steel containers. At service stations, certain plastic components on gasoline pumps need to be replaced with methanol compatible equivalents, again at a modest cost.

(4) Gas Supplies for Methanol Production

The accompanying table illustrates world gas usage rates and proven reserves with data taken from the World Survey of Natural Gas, published by Petroleum Economist in August 1987. Gas supplies have been broken down by region, while free world non-OPEC gas is also shown in order to facilitate application of energy security criteria.

Addressing specific points, we anticipate that the lowest methanol production costs will be associated with fuel methanol complexes each manufacturing one billion gallons of methanol per year. Such a complex will consume two trillion cubic feet of natural gas over a twenty year life. Since the Administration's proposal calls for one million clean cars per year by the year 2000, a total fleet of five million methanol vehicles running on M85 would require four to five fuel methanol complexes to supply the fuel, i.e., about 5% of U.S.A. total needs. Our needs could therefore be met from non-OPEC free world gas reserves for a period of 800 years. It should be appreciated that these figures are based on fully proven gas reserves; probable reserves are much higher. In many areas of the world without a ready gas market further gas exploration is not a priority.

The accompanying attachment, taken from the EPA report "Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel," September 1989, describes the existence of large amounts of vented, flared or re-injected gas able to account for about half the total U.S.A. gasoline demand, if converted to methanol. In total there are therefore ample quantities of natural gas to assure U.S. supplies of methanol in the foreseeable future.

(5) Pipelines

At least two pipeline tests have been done in North America in recent years, Edmonton Alberta to Vancouver British Columbia, and Edmonton to Windsor Ontario. Both tests demonstrated the viability of delivering methanol by pipeline for fuel applications, including "batching" with crude oil and oil products, without modifications being required to the pipeline.

In summary, the infrastructure requirements for the delivery and storage of fuel methanol are with a few minor modifications, the same as those required for gasoline and diesel.

AMERICAN METHANOL INSTITUTE

WORLD: COMMERICIAL PRODUCTION OF NATURAL GAS AND PROVEN RESERVES IN TCF (trillions cubic feet)

AREA	COMMERICIAL PRODUCTION (1986)	FULLY PROVEN RESERVES (1987)	RESERVES AS % WORLD	LIFE OF RESERVES (YRS)
USA	15.0	174	5.0	12
CANADA	2.6	92	2.7	35
CARIBBEAN	1.7	179	5.2	100
SOUTH AMERICA	0.7	39	1.1	50
MID EAST	2.1	873	25.3	100
AFRICA	1.9	237	6.9	100
WESTERN EUROPE	6.4	182	5.3	29
FAR EAST	4.0	280	8.1	66
USSR & E. EUROPE	25.0	1,394	40.4	56
TOTAL	59.4	3,450	100.0	57
EXC USSR, OPEC & E. EUROPE	28.7	838	24.3	0

Note: Derived from Petroleum Economist, August 1987

Potential Natural Gas Feedstock Availability for Future Methanol Fuel Production Facilities

The production of crude oil often includes a significant quantity of natural gas that is produced along with the crude oil. This "associated" gas is considered a nuisance in remote areas where there is no local market for the gas. Therefore, much of the gas is simply vented or flared. According to DOE estimates, the worldwide volume of natural gas which is vented and flared annually (a contributor to global warming) is roughly 2,975 billion cubic feet (bcf). Using existing conversion technology, this volume of gas would translate into about 31 billion gallons of methanol annually. More than twice this volume of gas is produced with petroleum and is currently being reinjected into oil reservoirs (6151 bcf per year or 64 billion gallons of methanol per year). While some of this gas is used to maintain reservoir pressure, an established methanol fuel market would likely attract a portion of this low-value gas.

Combined, this unmarketed natural gas could supply a total of 95 billion gallons of methanol per year, equivalent to about half the gasoline currently used in the U.S. As can be seen in Table 1, roughly 20 percent of this gas is located in the United States, the majority from the North Slope of Alaska. Approximately 30 percent is located in Africa, 10 percent in South America, 6 percent in the Far East, and 5 percent in Western Canada. Only about 15 percent of flared, vented, or reinjected gas is produced in the Middle East.

Vast quantities of natural gas are co-produced on the Alaskan North Slope and are currently reinjected into the oil reservoirs at significant cost, because there is no pipeline to transport the gas to market. If the gas is converted to liquid methanol, tests have shown that the methanol could be transported through the Trans-Alaskan pipeline to tankers in Valdez. At current reinjection rates this gas could be used to produce approximately 14 billion gallons of fuel methanol annually.

Looking at the long-term picture, estimated proven natural gas reserves total 3,797 trillion cubic feet (tcf) worldwide. Since most of the natural gas reserves have been discovered as a result of oil exploration, projected natural gas resources are much greater.

Note: Taken from Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel, September 1989, Environmental Protection Agency.

LEON GREEN, JR. · 2101 CONNECTICUT AVENUE · WASHINGTON, D. C. 20008 · 202 483-5950

October 10, 1989

Honorable J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
364 Dirksen Senate Office Building
Washington, DC 20510

Dear Senator Johnston:

Enclosed is a copy of an ASME preprint "Emission-Free Production of Methanol by Flame-Free Gasification of Coal" to be presented at the 1989 Joint Power Generation Conference in Dallas, Texas, October 22-26, 1989.

This paper is relevant to testimony to be received by your Committee concerning the appropriate role of methanol fuel in our future energy policy on Tuesday, October 17, and I am writing to request that it be included in the record of the hearing.

The point of the paper is that technology called for in Public Law 100-94 for producing methanol from coal without large emissions of carbon dioxide has already been demonstrated in the Federal Republic of Germany, but its elements have not been integrated. In this short paper and in a more extensive version published in the Proceedings of the 6th Annual International Pittsburgh Coal Conference, I advocate a pilot-scale demonstration of coupled nuclear process heat and combustion-free gasification to produce synthesis gas ($CO + H_2$) and hence methanol.

In a meeting on September 20, 1989 with representatives of the DOE Deputy Assistant Secretary for Policy, Planning and Analysis I pointed out the existence of this foreign technology and recommended an evaluation the feasibility of performing such an integrated, pilot-scale demonstration in northern West Virginia, a region producing high-sulfur coal, a major U.S. resource whose continued use is jeopardized by environmental protection requirements.

One of the scheduled witnesses at your October 17 hearing, Dr. Jim MacKenzie of the World Resources Institute, has repeated argued against the production of methanol from coal because of the large quantities of CO_2 emitted by conventional gasification processes. My paper points out that, by application of the "third generation" flame-free process, this need not be the case.

Yours sincerely,

Enclosure

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
345 E. 47 St., New York, N.Y. 10017

89-JPGC/EC-2

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Printed in USA.

Emission-Free Production of Methanol by Flame-Free Gasification of Coal

LEON GREEN, JR.
Consultant
Washington, DC

ABSTRACT

Mitigation of the greenhouse effect will require a shift in power plant fuels away from coal and oil to less carbonaceous fuels. One candidate is methanol, which is now produced primarily by reforming of natural gas. While large, U.S. natural gas reserves are limited, and will eventually have to be supplanted by coal. To avoid the generation of CO_2 in conventional gasification processes, the new process should not use heat from internal combustion of coal but exogenous heat from a high-temperature nuclear reactor. Such process heat and gasification technologies have been developed in the Federal Republic of Germany and are ready for combined pilot demonstration. Methanol derived from the synthesis gas so produced can serve as a practical low-emissions fuel for both stationary and non-stationary power plants.

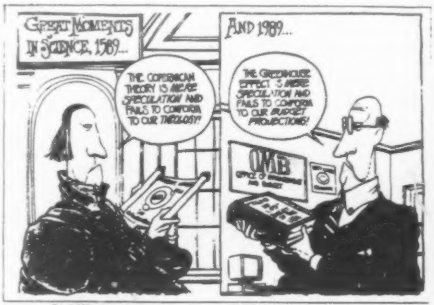
INTRODUCTION

> The "greenhouse effect" has never been in doubt (Schneider, 1989).

The reality of the "greenhouse effect" is no longer questioned by active workers in the field: "If there were a secret ballot at this meeting, most people would say the greenhouse warming is probably there" (Grotch, 1989). Only their public statements are conditioned with well-disciplined professional equivocation.

The controversial issue now is the rate and projected extent of global warming and its climatic and economic consequences. Moreover, the controversy has now assumed political as well as scientific dimensions which cannot be technically or editorially dismissed.

Embarrassed by an effort by the Office of Management and Budget to alter the testimony of an outspoken NASA investigator that the rate of warming is actually accelerating (Shabekoff, 1989a,b; Fig. 1), the Administration reversed its position of not committing the United States to an international conference on the subject and is now actively calling for one (Shabekoff, 1989c; Weisskopf, 1989).


GREAT MOMENTS IN SCIENCE, 1589...
THE COPERNICAN THEORY IS MERE SPECULATION AND FAILS TO CONFORM TO OUR THEOLOGY!
AND 1989...
THE GREENHOUSE EFFECT IS MERE SPECULATION AND FAILS TO CONFORM TO OUR BUDGET PROJECTIONS!
OMB

David Horsey
Seattle Post-Intelligencer

Fig. 1. Great moments in science

Back on the technical level, efforts center on control of emissions of the most important greenhouse gas, carbon dioxide. Since transportation systems are major emitters of CO_2 as well as the more noxious pollutants, interest in alternate fuels has heightened (Shabekoff, 1987; Wald, 1989) with methanol as an increasingly popular candidate (e.g., McGrory, 1989).

Presented at the Joint ASME/IEEE Power Generation Conference
Dallas, Texas—October 22-26, 1989

Methanol has long been studied as a motor fuel and has been evaluated in fleets of piston-engine vehicles (e.g., Graves and McGill, 1987) which have demonstrated reduced emissions of NO_x and CO. The action by California to promote use of methanol fuel for motor vehicles (Shabekoff, 1987) has, as expected (Shabekoff, 1989d), pre-saged national environmental policy. Less well known is the fact that methanol is also an excellent fuel for combustion turbines.

ENVIRONMENTAL BENEFITS OF METHANOL FUEL

Due to its oxygen content, methanol burns more efficiently than do hydrocarbons, producing low CO emissions noted above. More significant for use in gas turbines is its lower combustion flame temperature, which avoids the problem of coping with high NO_x emissions characteristic of turbines burning natural gas.

The experience with large gas-fired turbine installations in cogeneration systems, mostly in Texas and California, has been to require either moderation of flame temperature by injection of steam or water into the combustor or the use of costly catalytic converters with ammonia injection to reduce NO_x emissions in the exhaust.

Methanol, on the other hand, is in effect a hydrated hydrocarbon, CH_2:HOH. Indeed, the Mobil process for producing gasoline from methanol is based upon "dewatering" using a zeolite catalyst. Data on emissions from methanol-fueled gas turbines are scarce, but a test and evaluation of methanol in a utility gas turbine system was conducted in 1978 by the Southern California Edison Company with favorable results (Weir, et al., 1981).

The methanol tests totalling 523 hours were conducted on one engine comprising half of a 52-MW(e) baseload-rated twin engine installation while its twin burned petroleum distillate fuel (Jet A) or natural gas, with and without water injection sufficient to meet the EPA NO_x limit of 75 ppm. The emissions of the two engines are summarized for comparison in Table 1.

It may be seen that the NO_x emissions from the "dry" combustion of methanol were lower than those from the "wet" combustion of the hydrocarbons, and significantly lower than those from the corresponding "dry" combustions tests. The CO emissions from dry methanol were slightly greater than those from wet and dry Jet A tests but markedly lower than those from natural gas, either dry or wet. The same comparison applied to emissions of hydrocarbons and aldehydes. Methanol also yielded a slightly better heat rate than did either Jet A or natural gas.

Despite its superior performance, methanol was not deemed a viable utility fuel because of its limited availability and high cost relative to distillate fuel. Today methanol's low emission characteristics would weigh more heavily. By virtue of "carrying its own water," the operational advantage of methanol as a combustion turbine fuel for industrial power or electric utility power generation in high-air-pollution, water-short regions (e.g., the South Coast Air Quality Management District of California) would appear obvious.

CLIMATIC RESERVATIONS ABOUT METHANOL PRODUCTION

The reservations expressed about the use of methanol fuel concern not so much its combustion emissions but its method of production. Methanol is produced today almost exclusively by steam reforming of natural gas, using the heat of combustion of some of the gas to drive the endothermic reaction for reforming the remainder to produce synthesis gas, CO + H_2. The CO_2 produced by the combustion is considered acceptable since methane (CH_4) is low in carbon content.

Synthesis gas, and hence methanol, can also be produced by gasification of coal, but such a procedure is not considered desirable because conventional gasification processes also combust part of the coal to provide heat for gasifying the remainder, and coal (ca. $CH_{0.8}$) is high in carbon content. As result, the total CO_2 generated in gasification plus combustion of the methanol produced is considered unacceptable.

Table 1

COMPARATIVE COMBUSTION EMISSIONS FROM METHANOL
TURBINE FUEL TEST PROGRAM - BASELOAD CONDITIONS
(Weir, et al., 1981)

Fuel	Methanol	Jet A		Natural Gas	
	Dry[1]	Dry	Wet[2]	Dry	Wet[3]
Species (ppm)					
NO_x	45	207	56	124	65
CO	70	50	60	175	220
Hydrocarbons	10	5	5-6	216	280
Aldehydes	1.8	--	0.05	10.6	12.1

1. Without water injection
2. Water/fuel ratio by weight 0.5:1
3. Water/fuel ratio by weight 0.3:1

This fact, plus a recent estimate that the recoverable resource base of natural gas in the lower 48 States represents a 50-year supply at the current usage rate (DOE, 1988), has caused coal-to-methanol and other coal-based synfuel processes to be rejected categorically by natural gas advocates (e.g., MacDonald, 1988; MacKenzie, 1989; Gushee, 1988).

However, should the many switch-to-gas measures proposed as quick fixes for lowering CO_2 emissions be adopted, the increased demand will drastically reduce this estimated reserve, and gas will have to be supplemented and eventually supplanted by synthetic gas (SNG) from coal. It is thus strategically important to recognize the existence of an alternative zero-emissions gasification technology not involving combustion (Häfele, et al., 1986).

FLAME-FREE GASIFICATION

Flame-free gasification technology replaces the coal combustion heat in conventional processes with exogenous heat from an external source. From 1976 to 1984 a large pilot plant employing a fluidized-bed gasifier was operated at Bergbau-Forschung GmbH in Essen, Federal Republic of Germany, employing immersion heat exchangers carrying electrically-heated helium to simulate heat from a high-temperature nuclear reactor (van Heek, et al., 1982). During this period about 1,700 tons of anthracite and semi-anthracite coal and about 700 tons of bituminous coal were gasified by steam at a pressure of 40 atmospheres and a temperature of 800 C (Klusman and Stelzer, 1986).

NUCLEAR HEAT SOURCE

The reactor simulated was the 15-MW(e) AVR (Arbeitsgemeinschaftversuchreaktor) at the KFA (Kernforschungsanlage) Jülich GmbH. This plant was shut down at the end of 1988 after 21 years (more than its design lifetime) of successful operation delivering helium at temperatures up to 950 C for generation of high-availability, commercial electric power (Vollmer, et al., 1987). Such a temperature level is sufficient for coal gasification even when including an intermediate heat exchange loop for purpose of operational safety.

In regard to safety considerations, it is notable that, among its many operational tests, the AVR demonstrated the intrinsic safety of helium-cooled reactors by a simulated "loss of coolant" failure in which the cooling circulation was stopped under full power. Due to its intrinsic negative temperature coefficient of reactivity, the reactor shut down automatically and subsequently stabilized at a safely low level of activity (Vollmer, et al., op. cit.). Such intrinsic safety, plus its unequalled high-temperature capability, uniqely qualifies this gas-cooled reactor system for industrial process-heat applications.

CONCLUSION: TECHNOLOGY TRANSFER NEEDED

It may thus be seen that the elements of flame-free gasification technology have been successfully developed abroad. What remains to be demonstrated is their coupled operation. Unfortunately, the FRG program was concluded short of fruition because its original economic rationale (that fission heat would be cheaper than fossil heat) disappeared with the recent drop in oil prices.

In view of the new "climatic imperative" for reduction in CO_2 emissions, this technology should be re-evaluated as means of producing methanol from coal without such emissions, as explicitly mandated by Public Law 100-94 (100th Congress, 1988). A pilot-scale demonstration of flame-free gasification of (say) West Virginia coal would provide the basis for a realistic estimate of its economics (including environmental "externalities") prevailing ca. the year 2000. Such a demonstration would clearly be in the national and world interest and is strongly recommended.

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